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ABSTRACT

This guide contains instructor's materials for a three-unit secondary school course on circuit construction techniques. The units are breadboarding circuits, solder/desolder circuits, and printed circuit board repair. The document begins with advice on its use and a cross-referenced table of instructional materials that show which materials in the guide (transparency masters, handouts, assignment sheets, and test items) are directed at which competencies and instructional objectives. Each unit contains the unit objective, student objectives, a list of references, notes to the instructor, lesson plans, a unit test, and answers to the unit test. The lesson plans may include a glossary, information sheets, transparency masters, job sheets, assignment sheets, and test items. (CML)

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70-5004-I
Instructor's Guide

ELECTRONICS
Module

4

CIRCUIT CONSTRUCTION TECHNIQUES

ED315662

CE 054319

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ELECTRONICS

Module 4: Circuit Construction Techniques

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1989

Instructor's Guide
Catalog No. 70-5004-I

FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts and professionalism to develop curriculum for trade, technical and industrial education programs. This electronics guide is an outstanding example of what can be accomplished when the right people with the right attitude get together. Committee members worked hard over several years' time in advisory, writing, technical consultation and field-test capacities.

This guide is designed to be totally integrated with the Vocational Instructional Management System. It is hoped that all guides produced under our supervision will help classroom teachers manage instruction. A curriculum guide is more than a resource--it is an integral part of the management system. Rather than impeding instruction, it should guide and facilitate instruction.

This guide's format has been set up for competency-based teaching and testing. Unit tests evaluate specific competencies and can be used with the Vocational Administrative Management System (VAMS). Information sheets, transparency masters, job sheets, assignment sheets and test items are keyed to specific competencies. A cross-reference table has been included to quickly identify parts of the curriculum that relate to specific competencies. The material has also been packaged for students.

Although this guide may be a new format for some teachers, we are confident that, when used as designed, time spent by teachers and students will become more productive. Any future electronics curriculum modifications will begin with this guide. The electronics field is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

Judith Perryman, supervisor
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Department of Elementary and Secondary Education

Charles "Chuck" Waibel, director
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ACKNOWLEDGMENTS

This electronics guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). The guide has been keyed to the electronics competency profile developed by industry and education professionals in the state.

When searching for current electronics materials to adopt or utilize in the guide's development, comparable materials were found from the Mid-America Vocational Curriculum Consortium (MAVCC), of which Missouri is a member. MAVCC materials, therefore, have been relied upon as a resource for this guide. A debt of thanks is owed to the entire MAVCC organization for the research and development of these electronics materials.

Special appreciation is given to the writers (Ed Carter, John Chappell, Jim Everett, Bill Franken, Mark Murphy, Don Slack and Bill Tharp) for their self-motivation, reliability and technical expertise. IML employees Crystal Dietiker and Donna Curtis contributed greatly to the guide's production.

These industry representatives and educators contributed to the guide as members of the advisory committee.

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John Chappell, St. Fair Community College, Sedalia
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Norman Peterson, University of Missouri-Columbia (PAVTE)
Don Slack, Graff Area Vocational Center, Springfield
Lawrence Vance, Rolla AVTS
Mark Ward, Lewis & Clark Technical School, St. Charles

Support and contributions of IML staff members were instrumental to this module's development.

Harley Schlichting, director
Amon Herd, associate director
Phyllis Miller and Dan Stapleton, assistant directors
Crystal Dietiker, graphic artist II
Donna Curtis and Lori Holliday, word processors
Julie Bishop, student assistant - clerical
Wei Li, graduate assistant

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COMPETENCIES ADDRESSED IN THIS MODULE

A. Electronic Safety

4. Identify and practice safe soldering methods

B. Fundamentals of Electronics

16. Identify and replace parts and components on printed circuit boards and chassis
17. Interpret symbols and schematic diagrams

M. Circuit Construction Techniques

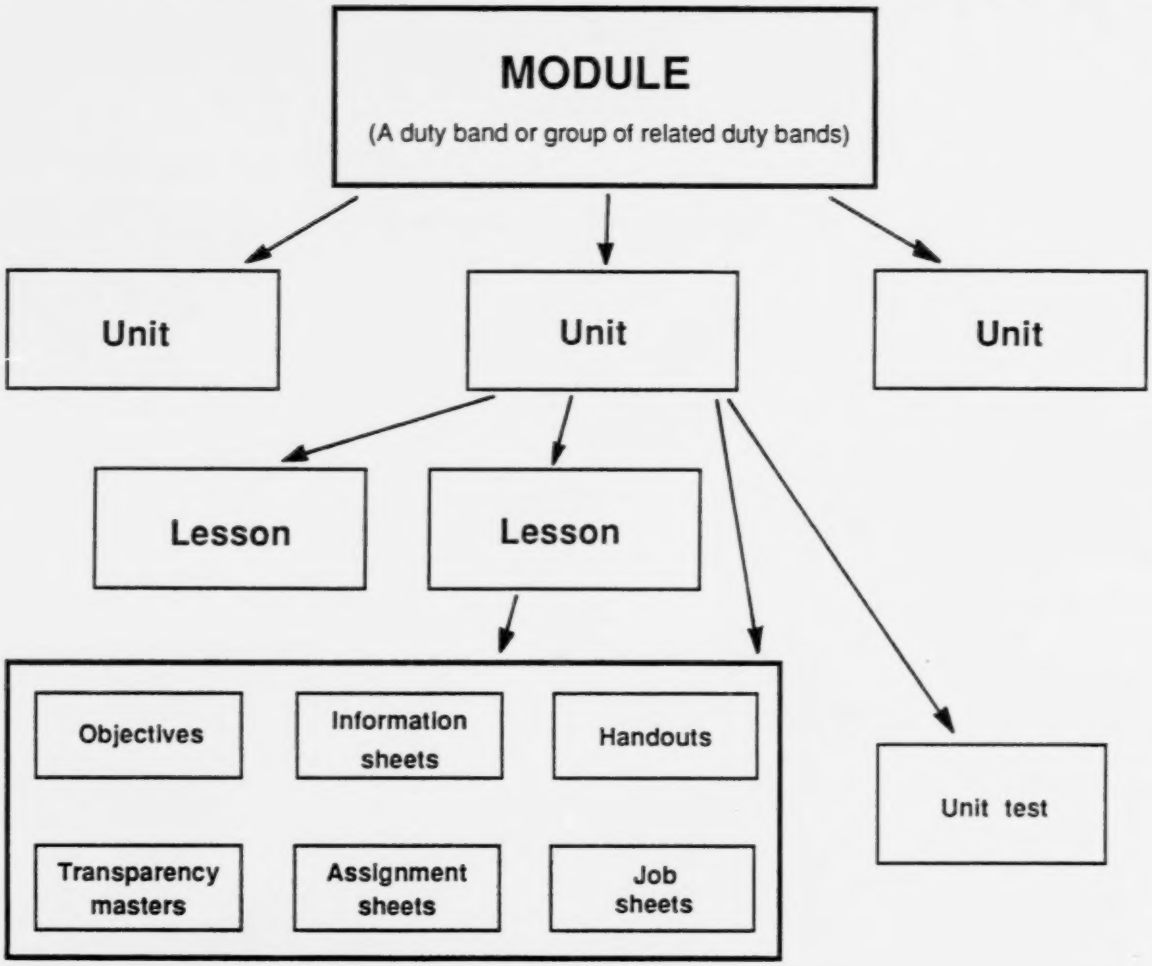
1. Breadboarding circuits
3. Solder/desolder circuits
4. Select and install proper components for specific use
5. Repair printed circuit boards

HOW TO USE THIS PUBLICATION

GUIDE COMPONENTS

Units of instruction

This Electronics guide contains ten modules of instruction. Within each module are instructional units including some or all of the following components: performance objectives, information sheets, transparency masters, handouts, assignment sheets, job sheets and a unit test. Special instructions on audiovisuals, supplies, etc. are included in the Notes to the Instructor section near the beginning of each unit.



Competency profile

On the Missouri competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral. To evaluate the student on performance of the competencies, a 3-2-1-N grading system is used, where:

- **3 = Mastery** - can work independently with no supervision
- **2 = Requires supervision** - can perform job completely with limited supervision
- **1 = Not mastered** - requires instruction and close supervision
- **N = No exposure** - no experience or knowledge in this area

Cross-reference table (color-coded white)

Once the numbering system is understood, this table quickly reveals how the instructional components of the module relate to Missouri competencies. On the competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral.

On the cross-reference table, unit numbers are represented by Roman numerals (I, II, III, etc.). Lessons within a unit are shown with Arabic numerals. Therefore, the first objective in Lesson 1 is numbered 1.1, the second is 1.2, and so on. Other components of the module (transparencies, handouts, assignment sheets and job sheets) also use this numbering system. By looking at the cross-reference table, the instructor can quickly determine what test questions or job sheets a student needs to receive an evaluation on a particular competency.

Objectives (color-coded white)

Each unit is based on performance objectives which state the measurable unit and specific behavioral or performance objectives that students are expected to achieve. Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the objectives' intent. Teachers should feel free to add/adapt objectives which will fit the material to student and community needs. Supporting material will, of course, need to be added for any new objectives.

Table of contents, references, notes to the instructor (color-coded pink)

These pages have been coded pink for instructor use only. The reference section lists materials used as sources in developing the material. Special instructions on audiovisuals, supplies, etc. are included in the Notes to the Instructor section.

Information sheets (green)

Presented in outline form for clarity, these pages provide content essential for meeting the cognitive (knowledge) objectives in the unit. Students should study the information sheets before class discussion or completion of assignment sheets. **CAUTION** statements indicate possible equipment damage, while **WARNING** statements recommend procedures to avoid bodily injury. Handouts and transparency masters have been keyed in the information sheets for instructional use.

Transparency masters (white)

Transparencies provide information by visually reinforcing or clarifying ideas presented in the information sheets. They are effective when identification is necessary and direct the class's attention to the topic of discussion. Transparencies should be left on the screen only when topics shown are under discussion, however.

Handouts (white)

Whenever more detailed information than can be presented in a transparency is needed, a handout is used. Handouts give the students additional information that can be kept with their class notes or student references.

Assignment sheets (tan)

Assignment sheets furnish paper-and-pencil practice to develop the knowledge necessary as a prerequisite to skill development. They can be given to students for class completion or used as homework assignments. Answer sheets (color-coded pink) can be used by the student or instructor to check progress.

Job sheets (blue)

These evaluation instruments are provided for two purposes: to outline steps of procedure and to check student performance mastery. Job sheets begin with a list of tools and materials needed for the activity. Job sheets furnish potential employers with a picture of skills being taught and performance which might

be reasonably expected from a vocational student. The spaces to the right of the page on a job sheet assist the instructor in evaluating a student on a particular activity. This 3-2-1-N grading system is the same as the one used on the competency profile.

Unit test (yellow)

Competency-based tests are designed to help eliminate subjective testing and to improve student evaluation and accountability. Specific competencies and test questions are linked on the answer key. These welding unit tests have been written to be used with computerized VAMS (Vocational Administrative Management System), utilizing Scantron sheets for computer-recording of test answers.

The unit test may be eliminated if the competency was thoroughly evaluated by job sheets. However, an emphasis should be placed on cognitive as well as performance skills. If the objective or competency will be evaluated by a job sheet, it is often necessary to determine by a written test whether the student understands enough of the material to perform the job sheet.

SUGGESTED ACTIVITIES

The following list of suggested activities may be helpful, especially to the beginning instructor.

1. Provide students with objective sheet and information sheets.
2. Discuss unit and specific objectives.
3. Discuss information sheets, assignment sheets and/or job sheets, lesson-by-lesson.
4. Have students do assignment sheet(s) to satisfactory levels.
5. Give students unit test.
6. After successful completion of the test, have students do job sheet(s).

Students should perform the following activities.

1. Read objective sheet.
2. Study information sheets.
3. Do assignment sheet(s).
4. Take unit test.
5. Do job sheets.

PACKAGING

This Electronics guide has been packaged with the entire class in mind. For the teacher, a complete instructor's guide contains all ten modules. In the student reference, selected portions have been reproduced for student use (objectives page, information sheets, handouts). Student work sheets (assignment sheets, job sheets, unit tests) have been packaged together for student distribution as the instructor deems necessary.

In the student reference, page numbers do not run consecutively because some pages have been removed that appear only in the instructor's guide.

MODULE 4: CIRCUIT CONSTRUCTION TECHNIQUES

CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Competency	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
M1	I 2.1-2.5		I 2.1	I 2.1	I 2.1		
M2							Not addressed
M3	II 2.3-2.6		II 2.2-2.6		II 2.1-2.3	II 43-50	
M4	I 1.3, 1.4, III 1.4		I 1.1, 1.2	I 1.1	III 1.1, 1.2	I 1-3,11,12,14-23	
M5	III 1.1-1.4				III 1.1, 1.2	III 1-7	
A4	I 1.1, 1.2, II 1.1-1.3,2.1, 2.2		II 1.1, 2.1	II 1.1		I 4,13,24,25, II 1-42	
B16	I 1.3, 1.4 III 1.4		I 1.1, 1.2	I 1.1	III 1.1, 1.2	I 1-3,11,12,14-23	Same as M4
B17	I 1.4					I 5-10	

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT I: BREADBOARDING CIRCUITS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify soldering safety hazards, select circuit components read a schematic diagram, select and safely use hand tools and breadboard a simple electronic circuit.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Match terms and definitions.

1.2 Explain possible safety hazards while soldering. (competency A4)

1.3 Identify characteristics of wire circuit conductors. (competencies B16, M4)

1.4 Identify common component parts and related schematic symbols. (competencies B16, B17 and M4)

2.1 Match terms and definitions.

2.2 Identify hand tools.

2.3 Differentiate between appropriate and inappropriate uses of breadboarding equipment.

2.4 Give examples of breadboard maintenance procedures.

2.5 Demonstrate the ability to breadboard a circuit. (competency M1, JS 2.1)

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT I: BREADBOARDING CIRCUITS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: COMPONENT PARTS

   a. Information outline

   b. Handouts

      HO 1.1: Types of wire conductors
      HO 1.2: Standard copper wire gauge sizes

   c. Assignment sheet

      AS 1.1: Component parts inventory

2. Lesson 2: TOOLS AND BREADBOARD METHODS

   a. Information outline

   b. Handout

      HO 2.1: Solderless circuit board

   c. Assignment sheet

      AS 2.1: Shop breadboard inventory

   d. Job sheet

      JS 2.1: Breadboard a circuit

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Douglas-Young, John. Illustrated Encyclopedic Dictionary of Electronics. West Nyack, NY: Parker Publishing Co., Inc., 1981.

2. Floyd, Thomas L. Principles of Electronic Circuits. Columbus, OH: Charles E. Merrill, 1981.

3. Fowler, Richard J. Electricity Principles and Applications. 2nd ed. St. Louis: McGraw-Hill, 1984.

4. Graf, Rudolf F. Modern Dictionary of Electronics. 6th ed. Indianapolis, IN: Howard W. Sams & Co., Inc., 1984.

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6. Hughes, Fredrick W. Basic Electronics: Theory and Experimentation. Englewood Cliffs, NJ: Prentice-Hall, 1984.

7. Malvino, Albert Paul. Semiconductor Circuit Approximations. 4th ed. New York: McGraw-Hill Book Co., 1985.

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9. Schuler, Charles A. Electronics: Principles and Applications. 2nd ed. New York: McGraw-Hill, 1984.

10. Schuler, Charles A.; Richard J. Fowler. Basic Electricity and Electronics. St. Louis: McGraw-Hill, 1988.

11. Weir, Walter. Electronic Circuit Fundamentals. Englewood Cliffs, N J : Prentice-Hall, 1987.

B. Curriculum guides

1. Hartman, Lonnie. Basic Electronics. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1987.

2. Robertson, L. Paul. Basic Electronics I. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1980.

3. Vorderstrasse, Ron. General Electronics Technician. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1987.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Demonstrate neatly wired circuit on shop breadboard.

2. Encourage student to purchase their own breadboard.

   a. Breadboard socket and parts

   b. Radio Shack 160-in-1 or 200-in-1 kit

3. Give student extra resistors and capacitors from which to make selection.

4. Answers to Assignment Sheet 1.1 are left to the instructor's discretion and shop set-up.

5. Job Sheet 2.1 can be used with any breadboard method. For JS 2.1, use a circuit of your own or the oscillator circuit shown on the unit test's schematic.

B. Suggested student activity

1. Practice breadboarding simple circuits. (Sirens and blinking light are popular with students.)

C. Suggested supplemental materials

1. Please . . . don't give me any static (1/2" video). Presentation by Dan C. Anderson at electrostatic discharge (ESD) workshop for McDonnell Douglas Corp., 1985. (Available for free loan from Missouri Vocational Resource Center, 10 London Hall, University of Missouri-Columbia, 65211. Telephone 800/392-7217 or 314/882-9610.

2. "Electrostatic Discharge." Special supplement to Douglas Service 42 (Oct. 1985). Available from:

   McDonnell Douglas Corporation
   Editor, Douglas Service magazine (Lou Shaver)
   Douglas Aircraft Company (73-30)
   3855 Lakewood Boulevard
   Long Beach, CA 90846
   213/496-5001

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT I: BREADBOARDING CIRCUITS

LESSON 1: COMPONENT PARTS

NOTE: To construct circuits the technician must be able to read and interpret schematic diagram symbols. Wires and component parts are then connected so that the completed circuit is exactly the same as the schematic diagram. Sometimes, in order to troubleshoot, the technician has to trace through a wired circuit and draw the schematic diagram to understand the function of the circuit. The ability to read the schematic diagram and construct the wired circuit is an important skill for the technician to master.

I. Terms and definitions

A. Accident--any unplanned event, occurring suddenly, which causes personal injury or property damage

B. Burn--injury that results from heat, chemical agents or radiation

C. Ground--common return to earth for AC power lines. Chassis ground or circuit ground is the common return to one side of the internal power supply.

D. Solder--alloy of lead and tin

E. Soldering--process of joining electrical connections at high temperatures with an alloy of molten lead and tin

F. Static electricity--electrical energy storage without current movement (examples: a charged capacitor, a battery not in use)

G. Tolerance--acceptable amount of variation from an indicated value

II. Hazards of working with soldering equipment

A. Burns

1. Solder iron burns

a. Temperature at the solder iron tip can be more than 800F.

b. Use solder irons with insulated handles.

c. Do not lay hot solder iron directly on work bench; use a stand to hold the hot iron.

d. Never try to pick up a solder iron by the tip--always use the insulated handle.

2. Solder burns

a. Molten solder temperatures can exceed 360F.

b. Do not touch molten solder or freshly soldered connections.

c. Do not flip excess solder from the solder iron tip; wipe tip with damp sponge or shop towel.

WARNING: Always wear safety glasses when soldering (state law).

3. Electrical burns

   a. Electrical burns can occur if the body contacts an electrical circuit.

   b. Frayed or cut electrical cords should be repaired or replaced immediately.

4. Chemical burns (or poisoning)

   a. Some chemicals used as cleaners or lubricants can be hazardous if ingested.

   b. Never put solder or any unknown substance in your mouth.

   c. Always wash hands thoroughly after direct contact with chemicals.

   d. Read labels for special handling instructions.

B. Gas inhalation--Electronic components exposed to high amounts of heat can burn and produce gases that, if directly inhaled, can cause lung and respiratory system irritation.

C. Electrical shock

WARNING: Electrical shock can occur if the body contacts an electrical circuit. It can cause serious burns and muscle damage and can kill a victim by stopping the heart or breathing--or both.

1. Repair or replace frayed electrical cords immediately.

2. Avoid soldering energized circuits.

D. Fire

1. Never use extension cords with solder irons. Fires result when electrical wires, heated because of an overloaded circuit, come in contact with flammable materials.

2. Always work at a clean, clear work station. Fires can occur if hot solder iron tips contact paper or other flammable materials.

E. Injury from misuse of soldering/desoldering tools

1. Never flip excess solder.

2. Always wear eye protection.

3. Always keep soldering iron on stand.

III. Circuit conductors (wires)

A. Types of wire (HO 1.1)

1. Solid

   a. Stiff

   b. Movement can cause wire to break

   c. Insulated (hookup)

d. Bare (bus)

2. Stranded

a. Flexible

b. Movement will not easily break wire

c. Insulated

3. Wire braid

a. Flexible

b. Used for ground connections

c. Used around other conductors for grounded shield

4. Coaxial

a. Solid or stranded inner conductor

b. Wire braid outer conductor

c. Used to carry radio frequency signals

d. Used for microphone and audio cables

5. Twin lead

a. Solid or stranded conductors

b. Heavy insulation between conductors

c. Used for TV antenna lead-in

6. Flat cable

a. Stranded conductors

b. Flexible

c. Multicolored or one color

d. If one color, one wire has a color stripe for identification.

e. Used to connect circuit boards together

f. Widely used in computers

B. Wire size (HO 1.2)

1. American Standard Wire gauge sizes

a. Larger number is smaller size.

b. Larger wire has fewer ohms per foot.

2. Most common sizes for electronics

   a. #18

   b. #20

   c. #22

   d. #24

C. Schematic symbols

1. Two methods of drawing on schematic

2. Dot used on schematic (preferred)

   a. Dot means conductors connected

   b. Lines crossing means conductors not connected

3. No dot used on schematic

   a. Lines crossing means conductors connected

   b. Line arched over line means conductors not connected

IV. Other common component parts

A. Fuse

1. Protects circuit from current overload. Current rating is important.

2. Schematic symbol

B. Switch

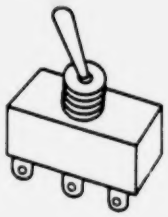
1. Used to control circuits

   a. Turn on or off

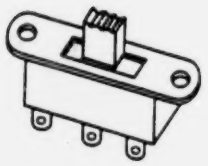
   b. Connect to different circuit

2. Physical types

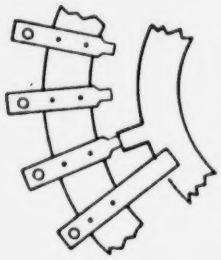
   a. Toggle



b. Slide



c. Rotary

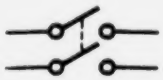


3. Circuit types

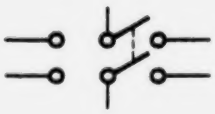
a. SPST (single-pole single-throw)

b. SPDT (single-pole double-throw)

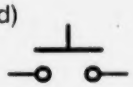
c. DPST (double-pole single-throw)



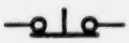
d. DPDT (double-pole double-throw)



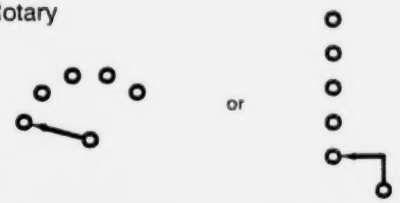
e. N.O. push button (normally open, on when pushed)



f. N.C. push button (normally closed, off when pushed)



g. Rotary



C. Speakers

1. Used for audio output; connect to power amplifiers

2. Schematic symbol

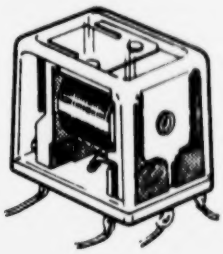
D. Battery

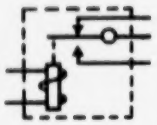
1. Used as power source for circuit

2. Snap fastener used to make connections

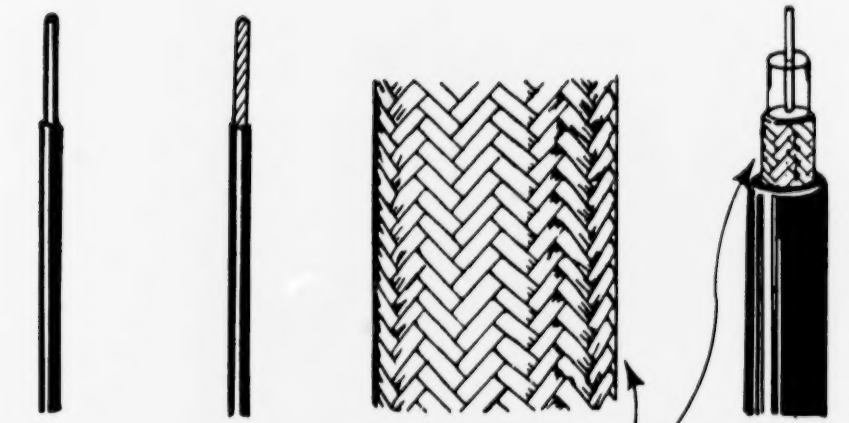
E. Relay

1. Switch operated by electromagnet
2. Used for remote control of circuits

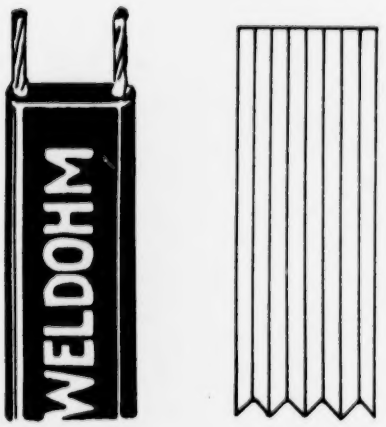




TYPES OF WIRE CONDUCTORS

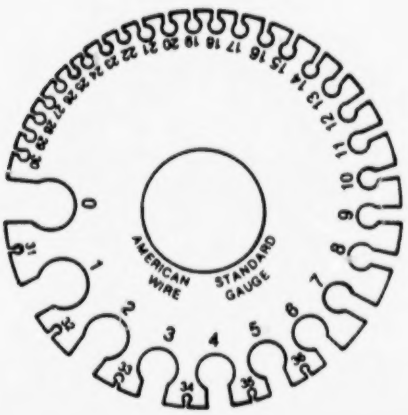


Solid Stranded Wire Braid Coaxial



Twin Lead Flat Cable

STANDARD COPPER WIRE GAUGE SIZES



AMERICAN STANDARD WIRE GAUGE

GAUGE NO.	DIAMETER, MILS	CIRCULAR-MIL AREA	OHMS PER 1,000 FT OF COPPER WIRE AT 25°C*	GAUGE NO.	DIAMETER, MILS	CIRCULAR-MIL AREA
1	289.3	83,690	0.1264	21	28.46	810.1
2	257.6	66,370	0.1593	22	25.35	642.4
3	229.4	52,640	0.2009	23	22.57	509.5
4	204.3	41,740	0.2533	24	20.10	404.0
5	181.9	33,100	0.3195	25	17.90	320.4
6	162.0	26,250	0.4028	26	15.94	254.1
7	144.3	20,820	0.5080	27	14.20	201.5
8	128.5	16,510	0.6405	28	12.64	159.8
9	114.4	13,090	0.8077	29	11.26	126.7
10	101.9	10,380	1.018	30	10.03	100.5
11	90.74	8,234	1.284	31	8.928	79.70
12	80.81	6,530	1.619	32	7.950	63.21
13	71.96	5,178	2.042	33	7.080	50.13
14	64.08	4,107	2.575	34	6.305	39.75
15	57.07	3,257	3.247	35	5.615	31.52
16	50.82	2,583	4.094	36	5.000	25.00
17	45.26	2,048	5.163	37	4.453	19.83
18	40.30	1,624	6.510	38	3.965	15.72
19	35.89	1,288	8.210	39	3.531	12.47
20	31.96	1,022	10.35	40	3.145	9.88

*20 to 25°C or 68 to 77°F is considered average room temperature.

COMPONENT PARTS INVENTORY

Examine the shop breadboard component parts kit. Find and identify the following parts. Give description and draw schematic symbol of the part. Lay the parts on this sheet to show the instructor.

Wire samples

1. Solid conductor hook-up wire
2. Stranded hook-up wire
3. Other types of wire

Other component parts in kit

	Name of part	Schematic symbol
4.		
5.		
6.		
7.		
8.		

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT I: BREADBOARDING CIRCUITS

LESSON 2: TOOLS AND BREADBOARD METHODS

NOTE: Breadboarding is usually done for quick, solderless connection of circuits. The circuit may be for a lab experiment to prove the related theory, or for design or trial of a new piece of equipment. Breadboarding is an important skill for the student or working technician to master since a circuit can be quickly built and tested with little damage to parts.

I. Terms and definitions (HO 2.1)

- A. Breadboard--to wire an experimental circuit, usually without soldered connections
- B. Bus--wire or rows of holes used to carry power or ground for convenient connection to circuit components
- C. Fahnestock clip--springy metal clip with components soldered to clip and wires insert through hole; old method of breadboarding, but clips are still available
- D. Jack--round female connector that accepts male plug
  1. Banana jack--often used on test equipment and by some commercial training systems
  2. Wire jack--small jack that accepts bare wire, used by some commercial training systems
- E. Solderless circuit board--plastic circuit board with holes laid out in rows of five. Each set of five holes is connected together on the board's underside, and wires inserted into the holes make electrical connection with wires inserted into other holes in the set. Used by most commercial training systems. Also called:
  1. Breadboarding socket
  2. Solderless breadboard
  3. Prototype board
- F. Spring connector--copper-coated spring used for solderless connection of wires and components; widely used in Radio Shack equipment lab kits
- G. Wire wrap--breadboarding method where special wire is wrapped snugly around metal pins with tool to make tight solderless connection
  1. Used for prototype breadboarding
  2. Used for final assembly of "one of a kind" circuits

II. Hand tool use, selection and maintenance

- A. Long-nose pliers
  1. Holding components
  2. Heat sink

3. Shaping and forming small conductors

B. Diagonal-cutting pliers

1. Cutting wire and component leads

2. Stripping insulation from wire

C. Adjustable wire strippers

1. Adjust to wire size

2. Stripping insulation from wire

D. Mechanical wire strippers

1. Adjust to length of bare wire desired

2. Cutting holes for several common wire sizes

3. Grips wire and strips in one motion

4. Used in production line work

E. Thermal wire strippers

1. Remove wire insulation by heating and melting material

2. Prevent wire strands

3. Cannot be used on insulation that does not melt

4. Used to strip wire-wrap wire

5. Used in production line work

F. Factors to consider when selecting hand tools

1. Tool size should be matched to the work most frequently encountered. Four- or five-inch pliers are best for electronics.

2. Tools should be specifically designed for electronic work when possible, such as insulation on handles.

G. Tool maintenance procedures

1. Pliers

a. Keep pliers clean and rust free.

b. Keep cutting edges sharp and smooth.

c. Keep pliers working freely.

d. Repair or replace damaged handle insulation.

2. Wire strippers

a. Keep strippers clean and rust free.

b. Keep cutting edges sharp and smooth.

c. Keep strippers working freely.

d. Keep strippers adjusted for most common size.

e. Repair or replace damaged handle insulation.

III. Breadboarding equipment and uses

A. Solderless circuit board

1. Reusable circuit board made of plastic

2. Rows of five holes for inserting wires

a. Spring clips in holes for gripping wires

b. Clips are connected together on underside of board so that the five clips in a row are electrically shorted together.

c. Up to five wires and/or component leads can be connected together without solder.

3. Center channel divides board in half.

a. Integrated circuits can straddle channel

b. Spacing of holes matches legs of IC.

c. Connections can be made to pins on each side of IC without short circuits.

4. Some have horizontal rows of holes around edge of board. One horizontal row can be used for power bus, while another row can be used for ground bus.

5. Loose components and wires are plugged into board to construct circuit.

6. Solid hook-up wire is used.

7. Most common type of breadboard method

8. Available in several sizes and from many manufacturers

9. Relatively inexpensive

10. Components parts easily lost

11. Power supplies attached to board on some solderless boards.

12. Used by most commercial training systems

B. Spring connector

1. Usually mounted on panel

2. Solderless connections to wires (Wires connect components together.)
3. Parts mounted to panel are not easily lost. Components are soldered to springs.
4. Solid or stranded hook-up wire is used.
5. Quick circuit construction possible.
6. Used by Radio Shack in 160-in-1 and 200-in-1 experiment kits

C. Jacks

1. Banana jack
   a. Same as used on test equipment
   b. Requires matching banana plugs on wire
   c. Jacks and plugs are expensive but durable.
   d. Stranded hook-up wire is used.
2. Wire jack
   a. Accepts common hook-up wire
   b. Jacks and plugs are expensive but durable.
   c. Stranded hook-up wire is used.
3. Jacks mounted on panel
   a. Banana jacks usually on metal panel
   b. Wire jacks usually on printed circuit panel
4. Solderless connections to wires (Wires connect components together.)
5. Parts mounted to panel are not easily lost. Components are soldered to jacks.
6. Quick circuit construction possible
7. Used by some commercial training systems

D. Wire wrap

1. Special tools required
   a. Hand-operated tool to twist wire
   b. Power tools available
2. Special wire required
   a. Small-gauge wire
   b. Light insulation, easily melted

3. Special pins required
    a. Pins or posts have sharp, square corners.
    b. Corners bite into wire.
    c. Pins inserted into perforated board
    d. Components soldered to pins
4. Used for prototype breadboarding
5. Used for final assembly
6. More difficult to master than other types
7. More expensive than other types

E. Fahnestock clip
1. Can be used on plastic or block of wood
2. Components soldered to clips
3. Wires insert into clips
4. More difficult to use
5. Not readily available
6. Solid or stranded hook-up is used.

IV. Breadboard maintenance procedures

A. Solderless circuit board
1. Large wires will damage grippers.
    a. The largest wire to use is 22 gauge.
    b. The largest component lead to use is the size of a one-watt resistor.
2. Grippers must be tightened occasionally.
    a. Remove paper backing.
    b. Remove metal gripper strips.
    c. Gently squeeze grippers with pliers.
    d. Replace metal gripper strips.

B. Spring connector
1. Handle springs gently.
    a. Bend to loosen spring and insert wire.

b. Bend to loosen spring and remove wire.

c. Pulling wires loose may damage spring.

2. Spring may pull loose from panel.

C. Jacks

1. Banana jacks

a. Nut and insulated washer may loosen.

b. Tighten nut with pliers.

c. Jacks are replaceable.

2. Banana plugs

a. Wire may pull loose.

b. Tighten screw or solder wire to plug.

c. Plugs are replaceable.

3. Wire jacks

a. Solder connection to PC board can break.

b. Resolder connection.

c. Jacks are replaceable.

SOLDERLESS CIRCUIT BOARD

The Solderless Circuit Board is a device that allows you to assemble electronic circuits without the use of solder. It makes for quick and easy costruction and is thus ideal for experimentation.
A Solderless Circuit Board comes supplied with your EKI Science Electronic Lab.
Lay the board in front of you, as shown in Fig 1.

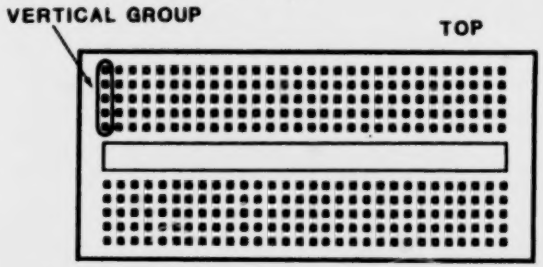
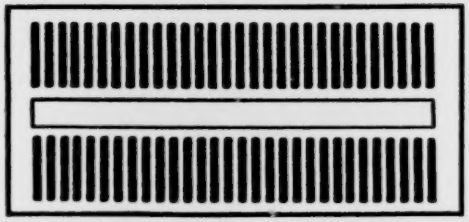


FIG. 1

Notice that there are many tiny holes in each board. Each hole will accept a component lead or wire. **All five holes in each vertical group or set are connected together.** Thus each vertical group is "shorted" together. Two or more wires or leads plugged into anyone of the five holes will be connected together. There are 60 sets of five holes.



UNDER SIDE OF SOLDERLESS CIRCUIT BOARD SHOWING METAL STRIPS WHICH CONNECT EACH SET OF FIVE HOLES. FIG. 2

A center channel separates or divides the board in half. Integrated Circuits are straddled across this channel as shown in Fig 3.
Also note that numbers and letters were printed on the board to help to identify each hole during the contruction process.

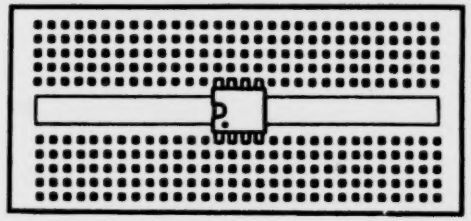
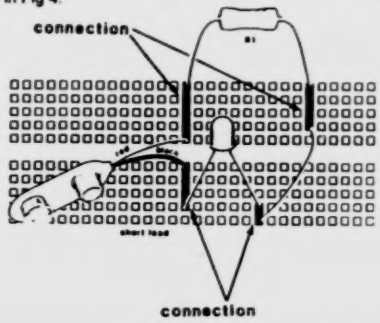


FIG. 3

In order to learn how to use the Solderless Circuit Board let us do the following experiment.
Let us say that we want to build a simple circuit to light up an LED, like the one shown in Fig 4.



In this circuit an electric current flows from the negative terminal of the battery to the positive terminal, passing through the LED and the resistor. As current flows through the LED, it illuminates.

Credit: Mr. Circuit Manual. Laguna Hills, CA: Electronic Kits International, Inc., 1985.

SHOP BREADBOARD INVENTORY

1. Describe the type of breadboard method(s) available in the shop.

2. Use catalogs or visits to stores to find description and price of three different types of solderless circuit boards.

Brand name	Description	# of connections	Price

3. Use catalogs or visits to stores to find description and price of two different types solderless circuit boards with power supplies.

Brand name	Description	# of connections	Price

4. Use catalogs or visits to stores to find description and price of pliers and wire strippers used in the shop.

Brand name	Description	Size	Price

BREADBOARD A CIRCUIT

NOTE: The following job sheet is for evaluation purposes only and is not an exact steps of procedure. The instructor will provide appropriate materials and schematic.

Equipment:

Needle-nose pliers
Wire stripper
Hook-up wire, assorted colors
Diagonal cutting pliers
Breadboard

Procedure:	Evaluation 3	2	1	N
1. Selection of components	—	—	—	—
2. Component layout	—	—	—	—
3. Lead dress	—	—	—	—
4. Parts polarity observed	—	—	—	—
5. Use of tools	—	—	—	—
6. Safety rules observed	—	—	—	—
7. Correct wiring	—	—	—	—
8. Circuit works	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competency M1: Breadboard a circuit and M4: Select and install proper components for specific use.

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT I: BREADBOARDING CIRCUITS

UNIT TEST

Select the option which best answers the question or completes the statement.

____ 1. Which of the following is <u>not</u> true?

a. Diagonal cutting pliers are used to strip insulation from wires.
b. Disk ceramic capacitors are not polarized.
c. Breadboarding is an important skill for the student to master.
d. Large-gauge wires inserted into the solderless breadboard will damage the wire grippers.
e. Stranded hook-up wire is best to use with the solderless breadboard.

____ 2. Which type of wire has multiple insulated conductors?

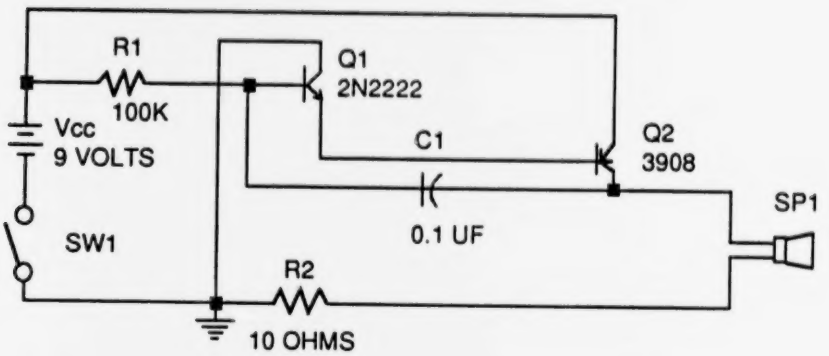
a. Bus
b. Flat cable
c. Solid
d. Stranded
e. All of the above

____ 3. Which size of hook-up wire is most commonly used in electronics?

a. 14
b. 15
c. 17
d. 20
e. 25

____ 4. Which statement is true?

a. Safety glasses must be worn when soldering.
b. Temperature at the soldering iron's tip is 100F.
c. Solder irons should rest in stands when not in use.
d. All of the above
e. Answers a and c



Based on the above schematic, match the term or phrase in the left column with the item in the right column.

____	5. Loudspeaker	a.	Vcc
____	6. Battery	b.	SW_1
____	7. SPST	c.	10Ω resistance
		d.	SP1
		e.	100KΩ resistor

Using the schematic, select the option which best answers the question or completes the statement.

____ 8. The loudspeaker is connected to the _____ .

a. Collector of Q2
b. Collector of Q1
c. Emitter of Q1
d. Base of Q2
e. None of the above

____ 9. The base of Q2 connects to the _____ .

a. Collector of Q1
b. Collector of Q2
c. Emitter of Q2
d. Emitter of Q1
e. None of the above

____ 10. Transistor Q1 is a(n) _____ .

a. PNP transistor
b. JFET transistor
c. NPN transistor
d. MOSFET transistor
e. None of the above

Match the following terms and definitions.

____ 11. An insulator, such as paper or plastic

____ 12. Common return to earth for AC power lines

____ 13. Process of joining electrical connections at high temperatures with an alloy of molten lead and tin

____ 14. Active devices that control current; made from silicon or germanium

____ 15. Electrical energy storage without current movement

____ 16. Acceptable amount of variation from an indicated value

____ 17. To wire an experimental circuit, usually without solderless connections

____ 18. Wire or rows of holes used to carry power or ground for convenient connection to circuit components

____ 19. Springy metal clip with components soldered to clip and wires insert through hole; old method of breadboarding

____ 20. Round female connector that accepts male plug

____ 21. Plastic circuit board with holes laid out in rows of five; wires inserted into the holes make electrical connection with wires inserted into other holes in the set

____ 22. Copper-coated spring used for solderless connection of wires and components; widely used in Radio Shack equipment lab kits

____ 23. Breadboarding method where special wire is wrapped snugly around metal pins with tool to make tight solderless connection

____ 24. Shop activity requiring the use of eye protection

a. Breadboard
b. Bus
c. Dielectric
d. Fahnestock clip
e. Ground
ab. Jack
ac. Semiconductors
ad. Soldering
ae. Solderless circuit board
bc. Spring connector
bd. Static electricity
be. Tolerance
cd. Wire wrap

25. List three safe practices to follow while soldering.

a.

b.

c.

ANSWERS TO UNIT TEST

1.	d	(B16, M4)
2.	b	(B16, M4)
3.	d	(B16, M4)
4.	e	(A4)
5.	d	(B17)
6.	a	(B17)
7.	b	(B17)
8.	a	(B17)
9.	d	(B17)
10.	c	(B17)
11.	c	(B16, M4)
12.	e	(B16, M4)
13.	ad	(A4)
14.	ac	(B16, M4)
15.	bd	(B16, M4)
16.	be	(B16, M4)
17.	a	(B16, M4)
18.	b	(B16, M4)
19.	d	(B16, M4)
20.	ab	(B16, M4)
21.	ae	(B16, M4)
22.	bc	(B16, M4)
23.	cd	(B16, M4)
24.	ad	(A4)

25. Any three safety practices discussed in this unit. (A4)

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT II: SOLDER/DESOLDER CIRCUITS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to select, safely use and care for hand and soldering tools. The student should also be able to make good soldered connections. This knowledge will be evidenced by completion of job sheets and the unit test to specified score.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Match terms and definitions associated with soldering.

1.2 Identify uses of hand tools and equipment.

1.3 Describe hand tool selection and maintenance procedures.

2.1 Match terms and definitions associated with circuit fabrication.

2.2 Match soldering tools and equipment with uses. (competency A4)

2.3 Identify true statements about solder and flux use in electronics.

2.4 Demonstrate the ability to:

a. Strip and tin wires for soldered connections. (competency M3, JS 2.1)
b. Splice wires together using various types of connections. (M3, JS 2.2)
c. Prepare solder iron tip and make good solder connections. (M3, JS 2.3)

2.5 Match types of poor solder connections with causes.

2.6 Match desoldering tools and processes with applications.

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT II: SOLDER/DESOLDER CIRCUITS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: CIRCUIT CONSTRUCTION TOOLS

   a. Information outline

   b. Handout

      HO 1.1: Hand tools

   c. Assignment sheet

      AS 1.1: Hand tool inventory

2. Lesson 2: SOLDERING TOOLS AND METHODS

   a. Information outline

   b. Handouts

      HO 2.1: Soldering tools
      HO 2.2: A good solder joint
      HO 2.3: Poor solder connections on a PC board
      HO 2.4: Soldered connections (without mechanical security)
      HO 2.5: Soldered connections (with mechanical security)
      HO 2.6: Types of desoldering tools

   c. Job sheets

      JS 2.1: Strip and tin wires for soldered connections
      JS 2.2: Splice wires together by soldering and crimping
      JS 2.3: Prepare solder iron tip and make solder connections

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Soldering. Heathkit Continuing Education. Benton Harbor, MI: Heath Co., 1977.
2. Douglas-Young, John. Illustrated Encyclopedic Dictionary of Electronics. West Nyack, NY: Parker Publishing Co., Inc., 1981.
3. Floyd, Thomas L. Principles of Electronic Circuits. Columbus, OH: Charles E. Merrill, 1981.
4. Fowler, Richard J. Electricity Principles and Applications. 2nd ed. St. Louis: McGraw-Hill, 1984.
5. Graf, Rudolf F. Modern Dictionary of Electronics. 6th ed. Indianapolis, IN: Howard W. Sams & Co., Inc., 1984.
6. Grob, Bernard. Basic Electronics. 5th ed. New York: McGraw-Hill, 1984.
7. Manko, Howard H. Solders and Soldering. New York: McGraw-Hill, 1964.
8. Schuler, Charles A. Electronics: Principles and Applications. 2nd ed. New York: McGraw-Hill, 1984.
9. Schuler, Charles A.; Richard J. Fowler. Basic Electricity and Electronics. St. Louis: McGraw-Hill, 1988.

B. Curriculum guides

1. Hartman, Lonnie. Basic Electronics. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1987.
2. Robertson, L. Paul. Basic Electronics I. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1980.
3. Vorderstrasse, Ron. General Electronics Technician. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1987.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Make solder practice board; attach several solder lug tie points to the board.
2. Demonstrate proper soldering technique.

B. Suggested student activity

1. Have students practice making solder joints.

C. Suggested supplemental materials

1. High Technology Soldering (videotape). Washington, DC: Consumer Electronics Group, Electronics Industries Association. (Available from EIA, 2001 Eye Street, N.W. 20006)

2. The Safety Factor (videotape). Katonah, NY: Circle Oak Productions, 1987. (Available with teacher's guide and quiz from 260 Katonah Ave. 10536, phone 914/232-9551)

3. Watson, C. Common Sense Desoldering (booklet). Covina, CA: Solder Removal Company (1077 East Edna Place, Covina, CA 91724). It has excellent diagrams demonstrating wicking techniques.

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT II: SOLDER/DESOLDER CIRCUITS

LESSON 1: CIRCUIT CONSTRUCTION TOOLS

NOTE: A good set of hand tools is essential for the electronic technician. Start a collection with a few good quality hand tools and add to them as needed. With proper care, good tools will last a lifetime.

I. Terms and definitions

A. Splice--to unite (connect) two wires to form a continuous length

B. Crimping--applying mechanical pressure to compress a sleeve-type or cup-type electrical terminal to ensure a good electrical connection between the sleeve and the conducting wires it contains

C. Land--printed wiring attached to the surface of a printed circuit board

D. Shrink tubing--plastic insulating sleeve which shrinks in diameter with the application of heat; used to insulate a splice

E. Stripping--removing insulation from electrical conductors

II. Uses of hand tools and equipment (HO 1.1)

A. Long-nose chain pliers

1. Holding components

2. Heat sink

3. Shaping and forming small conductors

B. Diagonal cutting pliers

1. Cutting wire and component leads

2. Stripping insulation from wire

C. Combination slip-joint pliers

1. Loosening small- to medium-size nuts and bolts

2. Holding and turning

D. Hole saws cut large holes in wood or metal.

E. Flat-blade screwdrivers are useful for removing or tightening slotted screws and bolts.

F. Phillips™ screwdrivers are useful in removing or tightening cross-point screws.

G. Torx™ screwdrivers remove or tighten star-headed screws.

H. Wire strippers cut and pull insulation from ends of conductors.

I. Electrician's six-in-one tool

1. Crimping solderless connectors
2. Cutting wire
3. Stripping insulation from wire
4. Cutting screws to length
5. Thread gauges
6. Length gauges for stripping

J. Adjustable wrenches are used to loosen and tighten nuts and bolts.

K. Hex and spline wrenches help loosen or tighten socket cap screws, nuts or bolts

L. Hemostat clamp

1. Grasping and picking up wires and small parts
2. Holding wires and small parts

M. Ball-peen hammer

1. Strike center punch
2. Straightening metal parts

N. Files

1. Removing burrs and sharp metal edges
2. Enlarge or elongate holes

O. Center punch

1. Mark metal for drilling holes
2. Prevents drill bit from "wandering"

P. Holes punches punch round or square holes in metal.

Q. Soldering iron stands support hot solder irons when not in use.

R. Heat sinks protect semiconductors from heat damage when soldering.

S. Component lead cleaners remove oxides from component leads before soldering.

T. Solder suckers are used to remove excess solder from connections and joints when desoldering.

U. Shrink tubing

1. Insulate and protect wire splice or component lead
2. Shrink when heated

V. Insertion or removal tool holds and inserts or removes integrated circuits

W. Drill and drill bits are used to drill holes in printed circuit boards and metal or plastic chassis parts.

X. Wire gauges determine wire size.

Y. The soldering vise holds parts and printed circuit boards when soldering.

Z. Crimping tools are used to crimp solderless connectors.

III. Hand tool selection and maintenance

A. Factors to consider when selecting hand tools

1. Match tool size to most frequent work.

2. Tools should be specifically designed for electronics.

3. When in doubt, consult an electronics technician or the instructor.

4. Select tools with cushioned, insulated handles.

B. Tool maintenance procedures

1. Screwdrivers

a. Regrind worn or damaged flat-blade screwdrivers.

b. Discard worn or damaged Phillips™ and Torx™ screwdrivers.

2. Pliers

a. Keep pliers clean and rust-free.

b. Keep cutting edges sharp and smooth.

c. Keep pliers working freely.

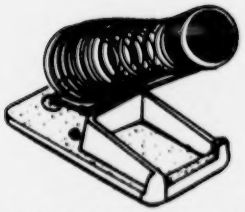
d. Repair or replace damaged handle insulation.

3. For adjustable wrenches, keep worm gears clean and lubricated.

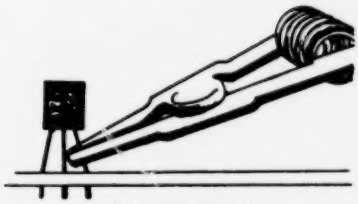
4. All tools should be identified by labeling with an electric vibrator pen or scratch awl.

HAND TOOLS

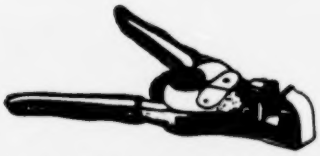
Solder Sucker



Soldering Stands

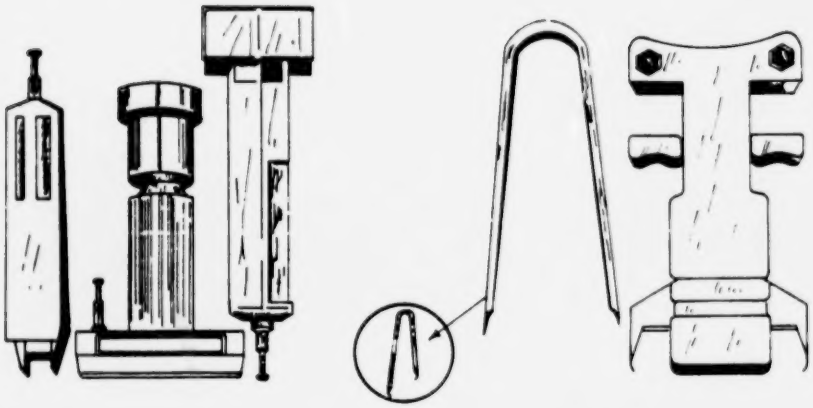


Heat Sink



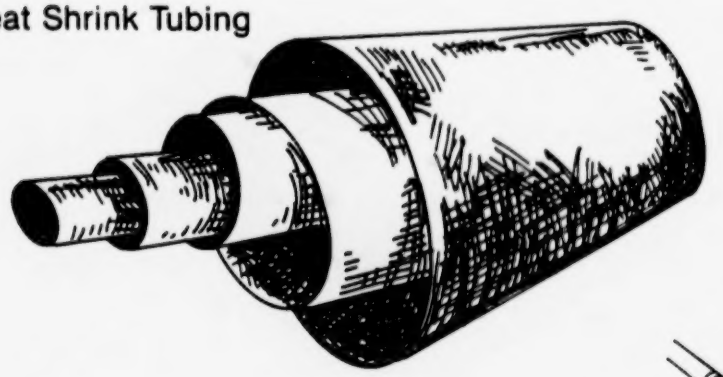
Mechanical Wire Strippers

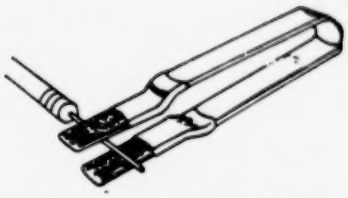
Thermal Wire Stripper



Insertion and Extraction Tools

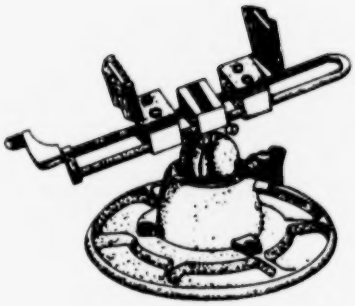
Heat Shrink Tubing



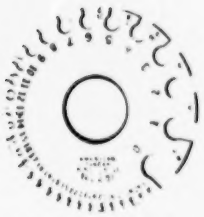


Component Lead Cleaner

Drill

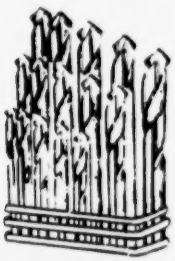


Soldering Vise



Wire Gauge

Open Barrel Type Crimp Tools



Drill Bits

HAND TOOL INVENTORY

Inventory the tools in your tool kit or those available for use in the shop. Use tool catalogs to find the approximate cost of each tool.

1. Screwdrivers

Brand name	Description	Cost

2. Pliers

Brand name	Description	Cost

3. Wrenches

Brand name	Description	Cost

4. Nut drivers

Brand name	Description	Cost

5. Solder Iron

Brand name	Description	Cost

6. Other tools

Brand name	Description	Cost

Total cost of tools _____

7. Other tools you would like to add to tool kit

Brand name	Description	Cost

Total cost of tools _____

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT II: SOLDER/DESOLDER CIRCUITS

LESSON 2: SOLDERING TOOLS AND METHODS

NOTE: The ability to solder is important to the electronics technician. Circuits can be constructed or repaired with soldered connections. Learn to be your own quality control inspector. Examine soldered connections and judge whether they are good or bad. Strive to be a craftsman by making each solder joint a professional one.

I. Terms and definitions

A. Eutectic--solder with tin/lead ratio of 63/37; has lowest melting point of 361°F

B. Flux--solution that cleans metals before or during soldering or chemically acts to aid the fusion process

C. Oxides--films and impurities which form on the surface of metals when exposed to air or water and which, if not cleaned off, will prevent a good bond between the surfaces and solder

D. Rosin--flux material obtained from pine trees which is used during soldering to help ensure a good bond between the solder and the metal surfaces

E. Solder--soft metal alloy of tin and lead used for plating or fusing metals together

F. Solder iron--electronically heated tool for heating joints hot enough to melt solder

1. Solder pencil--small iron, low wattage; preferred for most modern electronics soldering

2. Solder gun--pistol type, quick-heating solder iron for heavy duty soldering; can damage modern semiconductor components and printed circuit boards

G. Solder joint--junction of two or more metals fused with solder

H. Tinning--application of a small amount of solder to surfaces being soldered to help ensure good wetting during soldering

I. Wetting--ability of molten solder to flow over and fuse completely with metal surfaces to which it is applied

NOTE: Dirt, grease and oxides deter good wetting during soldering.

J. Wicking--flow of solder under the insulation of covered wire

II. Types and uses of soldering tools (HO 2.1)

A. Adjustable power source--for controlling soldering iron tip temperature

NOTE: Variac is a commonly used adjustable power source.

B. Component-lead cleaner--for removing oxides and other films from component leads

C. Crimping tool--for making a strong mechanical connection to certain sleeve-type terminals

D. Diagonal cutting pliers--for cutting conductors

E. Flux--for ensuring a good electrical connection by cleaning and wetting all surfaces during soldering. It is not required if the solder contains a rosin core.

F. Heat sink--for drawing heat from soldered connection to prevent damage to components

G. Heat-shrink insulation--sleeve-type insulation which, when heated, shrinks to form a snug fit over a soldered connection

H. Isopropyl alcohol--for removing oil, grease and flux from conductors and terminals both before and after soldering

I. Iso-Tip®, 10-36 watts--for soldering isolated electrical connections; eliminates electrical leakage and the need for grounding

J. Long-nose and needle-nose pliers--for making mechanical connection prior to soldering. These tools may also be used as heat sinks during soldering.

K. Mechanical-wire strippers--for cutting and pulling insulation from ends of conductors

L. Resistance soldering unit--for soldering many connections in close spaces

M. Solder--for making electrical connections. The most common type is 60/40 rosin-core solder containing 60% tin and 40% lead, with a center core of rosin flux to allow simultaneous application of both solder and flux.

N. Solder sucker--for removing melted solder from a terminal to be resoldered

NOTE: There are many different brands available, including Soldawick and Soldavac.

O. Soldering gun, 100-250 watts--for soldering large electrical connections when better heat control is required

P. Soldering iron, 100 watt--for soldering large electrical connections

Q. Soldering iron stand--for supporting a hot soldering iron when not in use

R. Soldering pencil, 10-40 watts--for soldering small electrical connections

S. Soldering vise--for clamping and holding a printed circuit board or other component during soldering or other repair operations

T. Spaghetti-sleeve insulation--for preventing electrical connections from becoming shorted to adjacent connections

U. Temperature-controlled soldering unit--for soldering many connections in close space or for production work

V. Thermal-wire strippers--for removing wire insulation by heating and melting the material. It prevents the removal of wire strands, but cannot be used on insulation that will not melt, such as glass braid or asbestos.

W. Typewriter eraser--for removing oxides and other films from terminals to be soldered

III. Solder and flux

A. Solder--used for making electrical connections; has a center core of rosin flux for simultaneous application of both solder and flux

1. Solder has three states.
    a. Solid when cool, holds connection firmly
    b. Plastic as melting occurs (Parts must not move until cool.)
    c. Liquid when melted (Solder must be liquid to make a good connection.)
2. 60/40 (60% tin and 40% lead)
    a. Most common type for electronics work
    b. Melts at 370°F
    c. Less expensive than eutectic solder
    d. Changes quickly from solid to liquid
    e. Has longer plastic state than eutectic solder
    f. Cools and hardens quickly
    g. Little heat damage to component parts
3. 63/37 (63% tin and 37% lead) eutectic solder
    a. Best for electronics work
    b. Melts at 361°F
    c. Much more expensive than 60/40 solder
    d. Changes quickly from solid to liquid
    e. Cools and hardens quickly
    f. Less heat damage to component parts
4. Solder for electronic applications is available in several forms: wire spools, bars, sheets, pellets, rings and washers.
5. Wire solders are most common for hand soldering.
    a. Diameter from 0.030" to 0.090"
    b. Larger sizes for general purpose work
    c. Smaller sizes used for delicate soldering such as PC boards and solder cup pins or connectors

B. Flux--chemical agent used to remove thin films of oxide present on the metal surfaces to be soldered. Flux attacks the oxides and suspends them in solution where they float to the surface during the soldering process. There are three major classifications of flux.

1. Chlorides (organic salts) are most active and highly corrosive. Do not use them for electronics hand soldering.

2. Organic (acids and bases)

   a. Slightly less active than chlorides

   b. Highly corrosive

   c. Do not use for electronic hand soldering.

3. Rosin (from pine trees)

   a. Noncorrosive at room temperature

   b. Corrosive at melting point of solder

   c. Only flux to use for electronics hand soldering

C. Primary purposes for solder in electronic applications

1. Makes connections with virtually no resistance to current flow

   a. Components soldered to printed circuit board

   b. Wires soldered to terminals and connectors

2. Prevents corrosion of conductors, connections and parts

   a. Coating with solder is called tinning. Printed circuit runs, terminal lugs and hook-up wires are often tinned with solder.

   b. Tinning with solder helps make soldered connections more quickly with less heat damage to component parts.

3. Makes connections mechanically stronger

   a. Soldered wires do not pull apart as easily as wires with only twisted connections.

   b. The weight of component parts is supported on the PC board.

4. Seals containers to keep out dust and moisture

   a. Radio frequency crystal canisters sealed with solder

   b. Encased transformers sealed with solder

   c. Encased relays sealed with solder

IV. How to solder

A. Observe safety rules when soldering.

1. Wear safety glasses (state law).

2. Solder iron is hot.

   a. Do not touch tip or barrel with fingers.

   b. Use soldering iron stand to hold hot iron.

c. Do not flip hot solder from iron.

d. Keep power cord off floor.

e. Keep hot iron away from flammable materials.

B. Select solder and solder iron for specific application.

1. Printed circuit boards

a. Select solder pencil or Iso-Tip® type, 15-25 watts.

b. Select small-diameter wire solder.

2. Boards with CMOS static-sensitive components

a. Select Iso-Tip® type, 15-25 watts.

b. Ground solder pencil type to work with clip lead.

c. Select small-diameter wire solder.

3. Large tie points, terminals and chassis grounds

a. Select larger pencil, 30-50 watts

b. Select 100-watt solder gun.

c. Select larger-diameter wire solder.

C. Prepare soldering tip prior to use.

1. Shape soldering iron tip.

a. File copper tip to wedge shape.

b. Remove pits and corroded areas.

c. Dress tip to bright, smooth copper.

d. Do not dress steel-clad copper tips.

2. Tin dressed tip with molten solder.

a. Wrap solder around tip.

b. Plug in solder iron power cord.

c. As tip heats, solder will melt on tip.

d. Coat entire dressed copper tip with solder.

e. If copper heats and oxidizes before tinning, cool tip and repeat filing and tinning process.

f. Tinned solder iron tip transfers heat to work.

g. Oxidized tip will not transfer heat to work.

D. Prepare area to be soldered.

1. Clean oxides from component leads and PC boards.

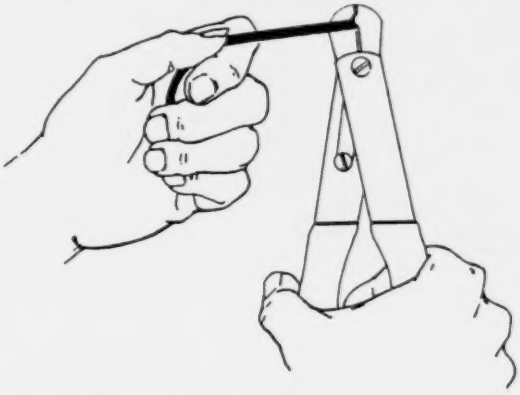
   a. Dark oxides prevent solder adhesion.

   b. A non-metallic kitchen scouring pad works well.

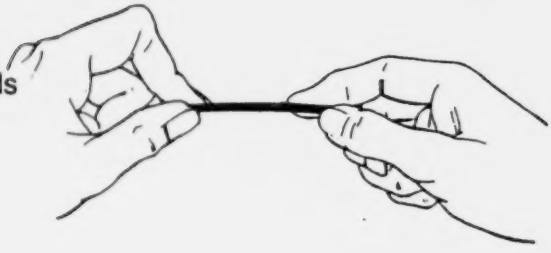
   c. Typewriter eraser

2. Prepare stranded wire before soldering.

With Wire In Proper Slot, Separate Insulation About ¼"



Using Slight Twisting Action To Keep Strands Intact, Remove Insulation From Wire



   a. Make a clean cut at the wire end by cutting off a small length with diagonal-cutting pliers.

   b. Lay the wire in the proper sized slot of wire strippers and strip approximately one inch of insulation from the wire end.

Correctly Adjusted

Incorrectly Adjusted

CAUTION: If too small a slot in the wire strippers is used for stripping, the stripper will cut off some of the wire strands. This could result in an electrical connection of higher resistance than desirable.

   c. Be careful not to remove wire strands when stripping.

d. If wire strands have been separated, gently retwist the wire in the same direction as the original twist.

e. After stripping, clean the wire strands with isopropyl alcohol and a paper towel.

f. Place a heat sink on the wire strands immediately adjacent to the wire insulation before tinning.

g. Melt a small bead of solder on the iron tip and slowly draw the bare wire through the solder bead from the heat sink toward the wire end. Apply additional solder as needed.

CAUTION: After the wire has been tinned, the outline of the wire strands should still be visible. If they are not, too much solder has been applied. Reheat the wire and wipe off the excess solder. If some strands are still loose, too little solder has been applied. Reheat wire and apply additional solder.

i. Remove the heat sink from the tinned wire.

j. After the solder has cooled, clean the tinned wire with isopropyl alcohol and a paper towel.

3. Position parts to be soldered.

a. Wrap component leads a half-turn around terminals.

b. Insert leads through holes in PC board.

c. Component parts mount on the opposite side of PC board from solder pads.

E. Tin solder iron tip.

1. Wipe molten solder and oxides from solder iron tip.

a. Use damp sponge or shop towel.

b. Keep tip tinned, bright and shiny.

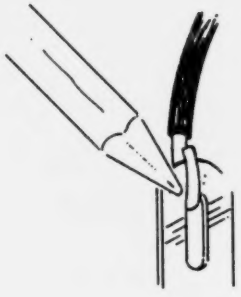
c. Oxides retard heat transfer to work.

2. Melt small puddle of solder on solder iron tip.

a. Molten solder puddle transfers heat quickly to work.

b. Keep tip tinned, bright and shiny.

c. Wipe tip and melt puddle before each solder joint.



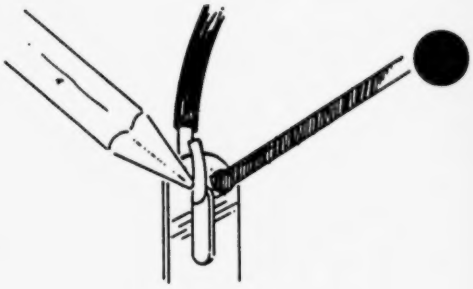
F. Make solder joint.

1. Heat the joint with solder tip.

a. Touch face of tip and puddle to <u>all</u> wires to be soldered.

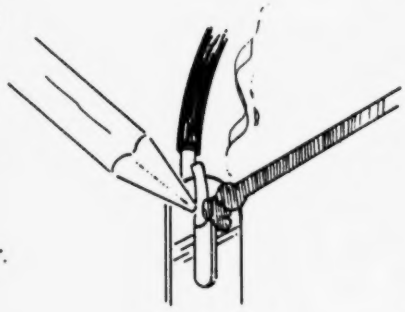
b. Let joint heat for 2-3 seconds.

2. Touch end of solder wire to joint.



   a. Touch solder to side of joint opposite the tip.
   b. Hold until solder begins to melt.
   c. Joint must be hot enough to melt solder.
   d. Some smoke should be visible from hot flux.

3. Remove solder from heat.



   a. Remove when solder flows and forms smooth contour.
   b. Strive for small amount of solder.
   c. Joint should be smooth and filled with solder.

4. Remove solder tip from joint.
   a. Wait about three seconds after removing solder.
   b. Do not let wires or joint move until cool.

G. Inspect work for quality joints. (HO 2.2, 2.3)

1. Good solder joints
   a. Bright silvery appearance
   b. Smooth contour
   c. Just enough solder to fill holes
2. Cold solder joints (not hot enough)
   a. Gray, crumbly appearance
   b. Sharp edges
   c. Work that has moved while cooling
   d. Wires that can pull loose easily
   e. Blobs of solder
   f. Heat joint, remove excess solder and do again.
   g. Joint must be hot enough to melt solder.
3. Rosin joint (not hot enough)
   a. Not smooth and shiny
   b. Rosin left inside joint (dark waxy blobs)
   c. Wires that can pull loose easily

d. Blobs of solder

e. Reheat joint and do again.

f. Joint must be hot enough to melt solder.

4. Solder bridges

a. Solder blob touching another part of circuit

b. Solder shorts across between terminals.

c. Solder shorts across another foil run on PC board.

d. Reason: too much solder

H. Wipe tip clean and repeat process for next solder joint.

V. Types of connections

A. No mechanical connection prior to soldering (HO 2.4)

1. Butt connections

a. No mechanical security

b. Wire-to-wire

c. Flat-to-flat

d. Seldom used on electronics circuits

2. Lap connections

a. No mechanical security

b. Wire to wire

c. Wire to flat

d. Flat to flat

e. Wire to post

f. Wire to cup or sleeve

g. Wire to hole

B. Partial mechanical connection prior to soldering (HO 2.5)

1. Wire-to-hook

2. Wire-to-flat lug

3. Wire-to-turret or post

C. Full mechanical connection prior to soldering

1. Wire spliced to wire
2. Wire to flat lug
3. Wire to turret or post
4. Wire to crimp sleeve

VI. Characteristics of a good solder connection (HO 2.2)

A. Silvery, shiny appearance to solder surface

B. Good wetting of solder to surfaces

C. Solder completely covers connection, but contour of connection is still visible

D. Insulation

1. No burnt areas
2. No damaged insulation
3. Gap between insulation and connection is approximately the diameter of the wire insulation

E. No spilled solder

F. No pits or holes in solder surface

VII. Types of poor solder connections and causes (HO 2.3)

A. Cold solder joint--insufficient heat

B. Disturbed joint--connection moved before solder solidified

C. Excessive solder--too much solder applied

D. Insufficient solder--too little solder applied

E. Dewetted solder joint--insufficient cleaning or use of flux

F. Burnt insulation--excessive heat or carelessness with iron

G. Insulation damage--excessive heat applied, excessive iron application time or lack of heat sink

H. Rosin solder joint--excessive rosin or insufficient heat

I. Solder short--excessive solder or carelessness

VIII. Types of desoldering tools and processes (HO 2.6)

A. Solder wick

1. Used to remove excess solder from the connection; made from finely woven wire

2. Process

   a. Place wick over solder to be removed.

   b. Place solder iron tip in contact with solder wick.

   c. Solder will melt and flow into wick in direction of heat transfer.

   d. Solder is trapped in strands of wick.

   e. Bend lead away from terminal pad and remove.

   f. Cut off and discard used wick.

B. Desoldering bulb

   1. Used for removing excess solder or desoldering leads

   2. Process

      a. Apply heat to area to be desoldered.

      b. Squeeze bulb and apply bulb tip to molten solder.

      c. Release bulb pressure.

      d. Liquid solder is drawn into the bulb.

      e. Repeat until solder is removed.

      f. Remove tip from bulb and clean out waste solder.

C. Solder sucker

   1. Used for removing excess solder or desoldering leads

   2. Process

      a. Push piston handle down until it engages trigger.

      b. Apply heat to joint to be desoldered.

      c. Insert solder sucker tip into molten solder.

      d. Release trigger on solder sucker.

      e. Spring pushes piston up, creating suction.

      f. Liquid solder is drawn into solder sucker.

      g. Disassemble solder sucker and remove waste solder.

      h. Use anti-static solder sucker with CMOS components.

D. Vacuum desoldering station

   1. Used to desolder ICs and components from PC board pads

2. Process

   a. Vacuum desoldering station has special solder iron.

   b. Attach hollow point tip that fits PC board pad.

   c. Turn on station and allow tip to heat.

   d. Insert tip over pad with wire inside tip.

   e. Heat pad and wire until solder melts.

   f. Turn on vacuum pump, drawing liquid solder into waste solder container.

   g. Turn vacuum pump off and remove tip from PC board.

   h. Vacuum desolder station is best for removing ICs from PC boards.

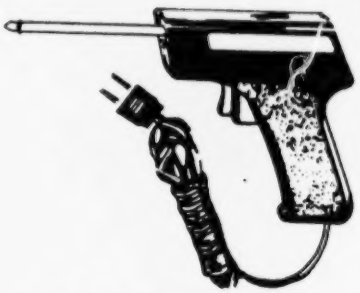
   i. Remove waste solder and clean filter after desoldering.

   j. Do not allow waste solder to harden in tool.

SOLDERING TOOLS

Iso-Tip

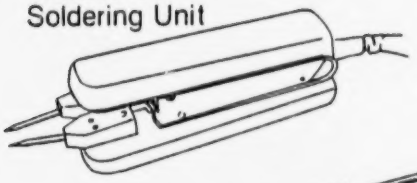
Soldering Pencil

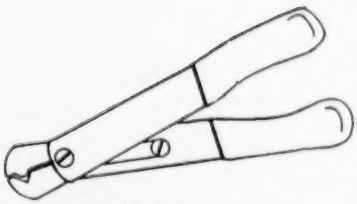


Soldering Gun

Temperature Controlled Soldering Unit

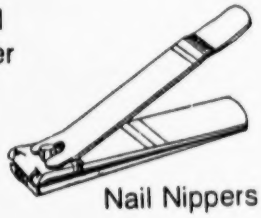
Resistance
Soldering Unit





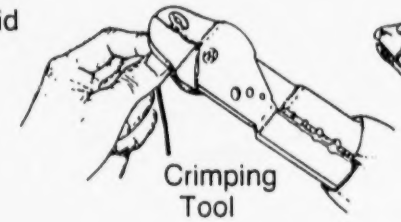
Mechanical
Wire Stripper

Soldering Aid



Nail Nippers

Heat Sink

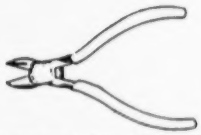


Crimping
Tool

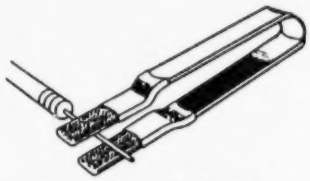
Long Needle-Nose Pliers

Long Chain Nose Pliers

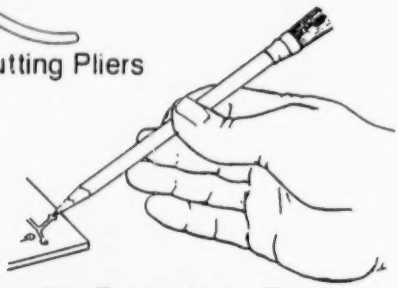
Electrician's Standard Size
Cutting Pliers



Diagonal Cutting Pliers

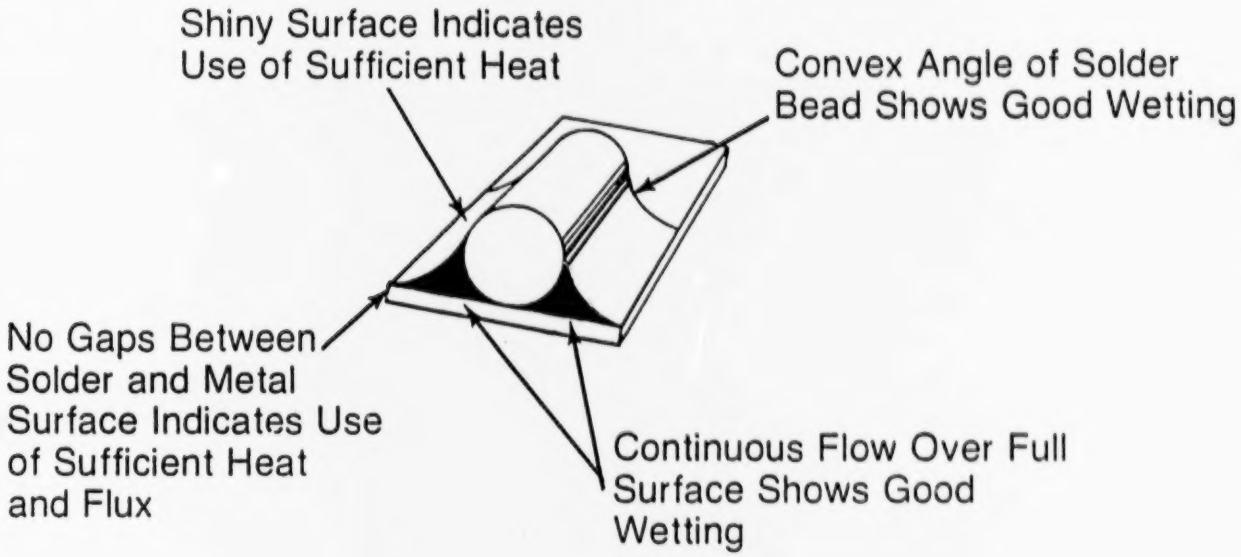


Component Lead Cleaner



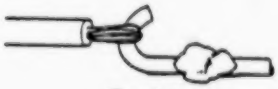
Typewriter Eraser Used To Mechanically Clean Parts To Be Soldered

A GOOD SOLDER JOINT

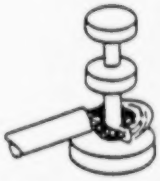


POOR SOLDER CONNECTIONS ON A PC BOARD

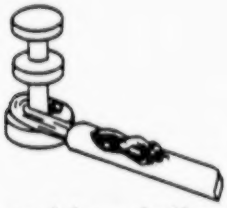
Insulation Damage



Solder Spill

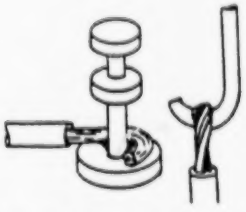


Insufficient Insulation Clearance

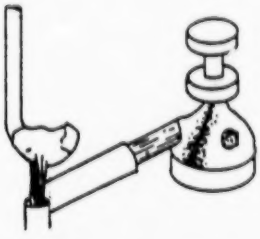


Damaged Insulation

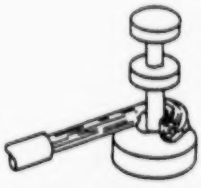
Insufficient Wire Wrap



Insufficient Solder



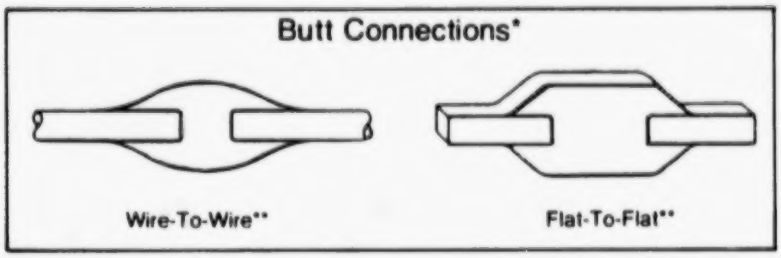
Excess Solder

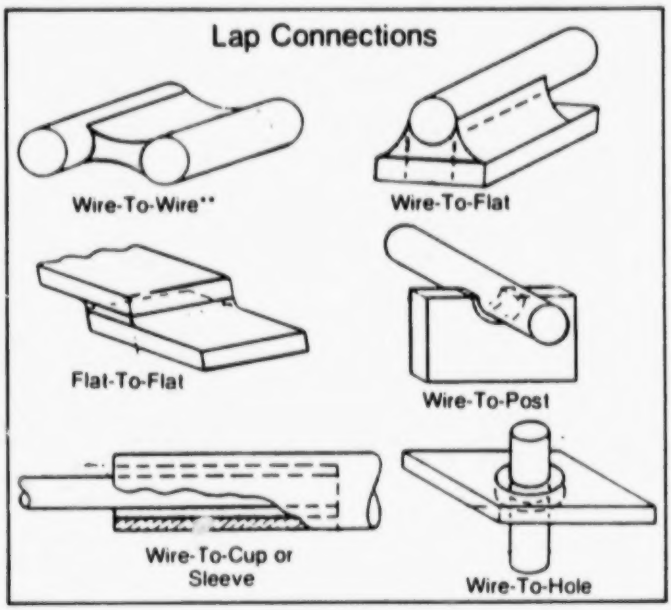


Excessive Insulation Clearance

Problem	Appearance	Cause
Cold joint	Dull silver color; poor flow	Insufficient heat
Disturbed joint	Chalky or crystallized; poor bond between solder and surface	Connection moved before solder solidified
Dewetted joint	Solder in globular form; poor bond at interface	Insufficient cleaning; insufficient use of flux
Burnt insulation	Insulation melted or blackened	Excessive heat; carelessness with iron
Insulation damage	End of insulation melted, lifted or curled	Excessive heat; excessive application time; lack of heat sink
Rosin joint	Rosin residue on surface or in joints of connection	Excessive rosin; insufficient heat
Solder short	Solder bridges to adjacent connection or to ground	Excessive solder carelessness when applying solder

SOLDERED CONNECTIONS (WITHOUT MECHANICAL SECURITY)

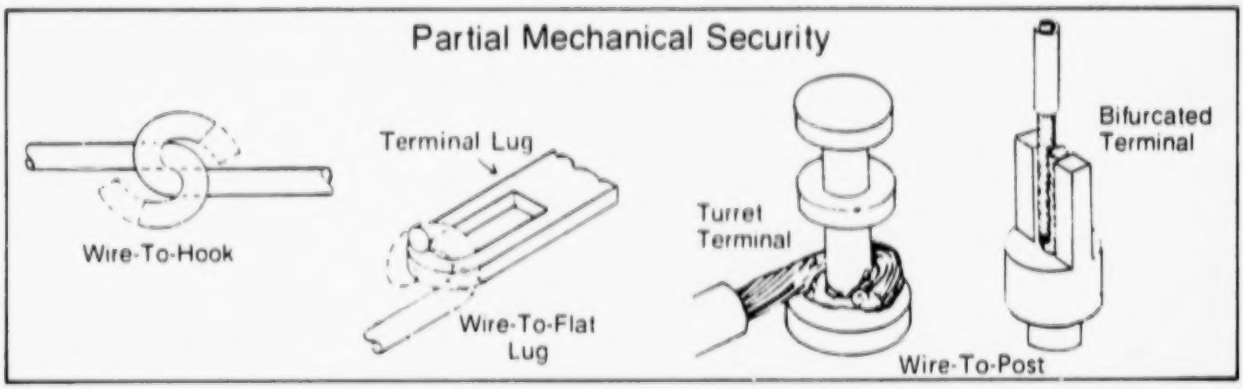


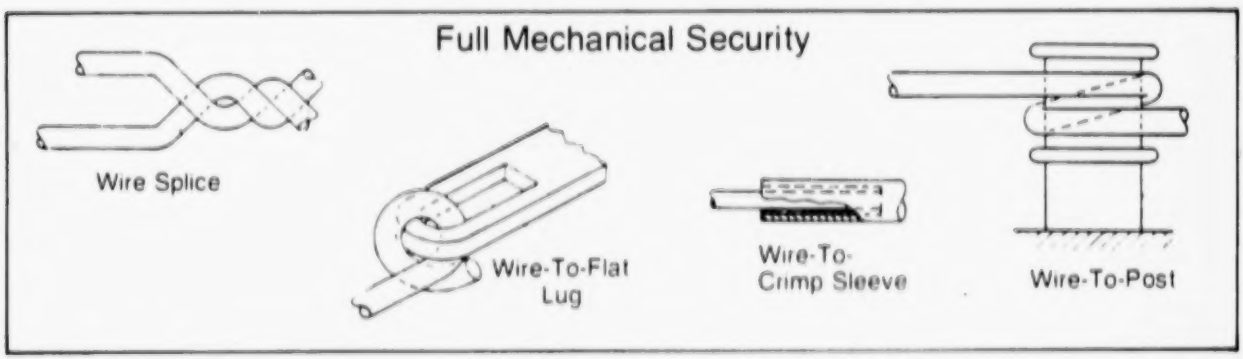


*Butt Connections are Seldom Used in Electrical Work

**These Connections Require a Fixture to Prevent Movement During Soldering

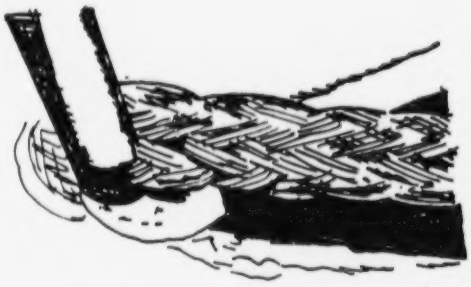
SOLDERED CONNECTIONS (WITH MECHANICAL SECURITY)





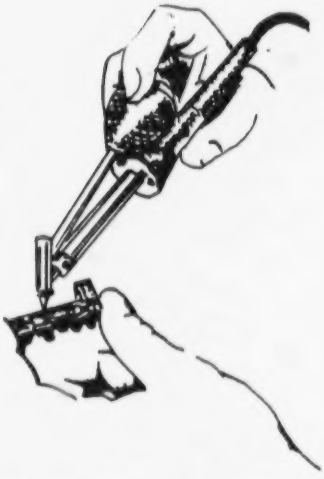
TYPES OF DESOLDERING TOOLS

Desoldering Bulb



Solder Wick

Solder Sucker



Desoldering Iron Attachment

STRIP AND TIN WIRES FOR SOLDERED CONNECTIONS

Equipment:

Soldering iron (20-30w)
60/40 rosin core solder (18 gauge)
Soldering iron holder
Mechanical wire strippers
Two six-inch lengths of 22-gauge stranded wire
Acid brush
Wire stripper
Damp sponge
Safety glasses

Procedure:		Evaluation 3	2	1	N
1.	Put on safety glasses.	—	—	—	—
2.	Plug soldering iron into AC outlet.	—	—	—	—
3.	As soon as the tip is hot, tin the iron tip; remove excess solder with a damp sponge.	—	—	—	—
4.	Using mechanical wire strippers, strip about one inch of insulation from each end of each wire length.	—	—	—	—
5.	Clean stripped wire ends with isopropyl alcohol and a clean cloth.	—	—	—	—
6.	Gently twist wire ends in direction of strand twist so that strands do not separate.	—	—	—	—
7.	Place wire end on heated iron tip and apply solder until solder freely flows among all wire strands; remove wire and solder.	—	—	—	—
8.	Clean tinned wire using isopropyl alcohol and acid brush.	—	—	—	—
9.	Check that excessive solder has not been applied (outline of all strands should be visible through the solder) and that wire insulation shows no evidence of burning or wicking.	—	—	—	—
10.	Repeat tinning operation.	—	—	—	—
11.	Ask instructor to check your work.	—	—	—	—
12.	Return equipment and materials to proper storage areas.	—	—	—	—
Average of above evaluation*		—	—	—	—

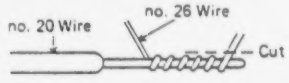
*This average is the student's partial evaluation for competency M3: Solder/desolder circuits.

SPLICE WIRES TOGETHER BY SOLDERING AND CRIMPING

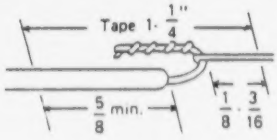
Equipment:

Soldering iron (20-30w)
Crimping tool
18 inches of #26 stranded wire
24 inches of #20 wire
One splice lug for #20 wire
Two inches of shrink tubing for #26 wire
Heat gun
Electrical tape
Safety glasses
60/40 rosin-core solder (22-gauge)

Procedure:	Evaluation 3	2	1	N
1. Put on safety glasses.	—	—	—	—
2. Cut the #26 wire into three equal lengths.	—	—	—	—
3. Strip, clean and tin one end of each length.	—	—	—	—
4. Cut the #20 wire into four equal lengths.	—	—	—	—
5. Strip, clean and tin one end of each length.	—	—	—	—
6. Trim tinned ends of all wires to 1/2 inch length.	—	—	—	—
7. Splice tinned ends of one #20 wire and one #26 wire.	—	—	—	—



a. Wrap smaller wire around larger wire.



b. Bend wires back and solder full length of twist.

c. Apply electrical tape over splice.

8. Install shrink tubing on one length of #26 wire.	—	—	—	—
9. Splice tinned ends of two lengths of #26 wire (including the one with the tubing).	—	—	—	—

a. Twist wires together.

b. Solder twisted ends.

c. Slide heat shrink tubing over splice.

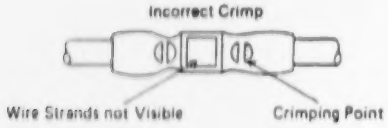
10. Shrink the tubing by applying heat across the length of the tubing without touching the tubing. — — — —

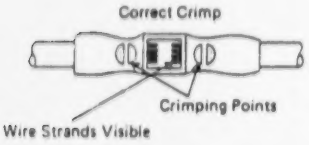
11. Continue applying heat until tubing fits snugly over the splice. — — — —

12. Insert tinned ends of two lengths of #20 wire in opposite ends of crimping lug; make sure strands of both wires are visible in slot at center of lug. — — — —

13. Using crimping tool, crimp both ends of lug. — — — —

14. Check that crimp is correct. — — — —





15. Return equipment and materials to proper storage areas. — — — —

Average of above evaluation* — — — —

*This average is the student's partial evaluation for competency M3: Solder/desolder circuits.

PREPARE SOLDER IRON TIP AND MAKE SOLDER CONNECTIONS

Equipment:

Solder pencil with copper tip
Damp sponge
60/40 wire solder with rosin core
Safety glasses
Long-nosed pliers
12" length of solid hook-up wire
12" length of stranded hook-up wire
Solder sucker
Fine wire brush
Fine metal file
Solder iron stand
Solder practice board
Diagonal cutting pliers
Resistors (2)
Ruler

Procedure:	Evaluation 3	2	1	N
1. Put on safety glasses. Observe safety rules while soldering. Prepare solder iron tip.	—	—	—	—
a. While the solder iron is cool and before connecting it to the power receptacle, inspect the tip.				
b. File the tip to a wedge shape without removing any more metal than is necessary.				
c. Remove any pits with file until tip is bright copper and the proper shape.				
2. Tin solder iron tip. Place solder iron in stand and connect power cord to receptacle. Place 60/40 solder against bright copper surface of tip. As tip heats, melt solder over all filed surfaces of tip. Wipe excess solder from tip with damp sponge.	—	—	—	—
3. Strip and tin wires.	—	—	—	—
a. Cut two 6" lengths of solid hook-up wire with the diagonal cutting pliers.				
b. Strip about 1/2" of insulation from each end of the two solid hook-up wires.				
c. Cut two 6" lengths of stranded hook-up wire.				
d. Strip about 1" of insulation from each end of the two wires.				
e. Twist the wire ends in the direction of strand twist so that strands do not separate.				

f. Touch solder to solder iron tip to make a puddle of melted solder.

g. Place twisted wire end in puddle, heating until solder flows among all wire strands.

h. Add small amount of solder if necessary. When solder flows among all wire strands, remove wire and solder.

i. Repeat tinning of remaining stranded wire ends.

5. Make mechanical wire connections. Bend U-shaped hook at end of each solid hook-up wire. Clip tinned stranded hook-up wires to about 1/2" length. Bend U-shaped hook at end of each stranded hook-up wire. Hook end of each wire around post or solder lug terminal. Gently squeeze hook tightly to terminal. — — — —

6. Solder wire terminal connections. — — — —

a. Clean solder iron tip with damp sponge.

b. Melt solder on cleaned tip to make puddle of melted solder.

c. Touch solder iron tip to one side of connection, touching both wire and terminal, heating for about three seconds.

d. Touch solder to other side of connection; let hot connection melt solder.

e. As solder begins to melt, pull wire solder away from connection.

f. Let solder iron tip continue heating connection for about three seconds; remove solder iron tip.

g. Do not move soldered connection while solder cools. Inspect solder connection for smooth, shiny surface. If soldered joint is either a cold solder joint or rosin joint, reheat and try again. If soldered joint is good, repeat for remaining wire connections.

7. Solder resistors to terminals. — — — —

   a. Place resistor between two terminals; cut resistor leads to length, leaving 3/8" to 1/2" extra length on each end.

   b. Bend hook on each end of resistor lead.

   c. Place one hook around solder lug and gently squeeze hook tightly to lug. Repeat with hook on other end of resistor.

   d. Wipe solder iron tip clean with damp sponge and tin tip with puddle of solder.

   e. Touch solder iron tip to one side of connection, touching both wire and terminal; heat for about three seconds.

   f. Touch solder to other side of connection; let hot connection melt solder. As solder begins to melt, pull wire solder away from connection. Let solder iron tip continue heating connection for about three seconds, then remove solder iron tip.

   g. Do not move soldered connection while solder cools. Inspect soldered connection for smooth, shiny surface. If soldered joint is either a cold solder joint or rosin joint, reheat and try again. If soldered joint is good, repeat for remaining resistor connections.

8. Desolder all connections. Apply heat with solder iron tip to one of the solder joints. As solder melts, pry wire off of lug. While still applying hot iron tip, remove molten solder with solder sucker. Repeat to desolder each solder joint. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competency M3: Solder/desolder circuits.

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT II: SOLDER/DESOLDER CIRCUITS

UNIT TEST

Match terms and soldering on the right with definitions and uses on the left.

____ 1.	Applying mechanical pressure to compress a sleeve-type or cup-type electrical terminal to ensure a good electrical connection	a.	Component lead cleaner
____ 2.	Application of a small amount of solder to surfaces being soldered to help ensure good wetting during soldering	b.	Crimping
____ 3.	Films and impurities which form on the surface of metals when exposed to air or water; will prevent a good bond between the surfaces and solder if not cleaned off	c.	Flux
____ 4.	Printed wiring attached to the surface of a printed circuit board	d.	Heat sink
____ 5.	Material obtained from pine trees which is used during soldering to help ensure a good bond between the solder and the metal surfaces	e.	Land
____ 6.	Removing insulation from electrical conductors	ab.	Oxides
____ 7.	Ability of molten solder to flow over and fuse completely with metal surfaces to which it is applied	ac.	Resistance soldering unit
____ 8.	Liquid or solid which, when heated, cleans and protects surfaces to be soldered	ad.	Rosin
____ 9.	For soldering large electrical connections	ae.	Soldering gun, 100 watt
____ 10.	For soldering small electrical connections	bc.	Soldering iron, 100 watt
____ 11.	For soldering large electrical connections where better heat control is required	bd.	Soldering pencil, 10-35 watts
____ 12.	For soldering connections in close spaces	be.	Stripping
____ 13.	For drawing heat from soldered connection to prevent damage to components	cd.	Tinning
____ 14.	For removing oxides and other films from component leads	ce.	Typewriter eraser
____ 15.	For removing oxides and other films from terminals to be soldered	de.	Wetting

Choose the option which best answers the question or completes the statement.

___ 16. Which of the following is not a solder state?

a. Gas
b. Liquid
c. Plastic
d. Solid
e. All of the above

___ 17. Which of the following is false?

a. Flux is a cleaner that removes oxides.
b. The most commonly used solder in electronics is 60/40.
c. Solder is made from iron and tin.
d. Rosin flux is the only flux to use in electronics.
e. Molten solder is hot enough to injure the eye.

___ 18. Which is a characteristic of a good solder connection?

a. Silvery, shiny appearance to solder surface
b. Dull appearance
c. Damaged insulation
d. Gap between insulation and connection is approximately 3/4"
e. None of the above

___ 19. A good solder connection has _____ .

a. Good wetting of solder to surfaces
b. Solder which does not always completely cover the connection
c. Small pits or holes in solder surface
d. Solder spills
e. All of the above

Match the types of poor solder connections on the right with causes on the left.

___ 20. Insufficient heat

___ 21. Connection moved before solder solidified

___ 22. Too much solder applied

___ 23. Too little solder applied

___ 24. Insufficient cleaning; insufficient flux use

___ 25. Excessive heat or carelessness with iron

___ 26. Excessive heat applied, excessive iron application time or lack of heat sink

___ 27. Excessive rosin or insufficient heat

___ 28. Excessive solder or carelessness

a. Burnt insulation
b. Cold solder joint
c. Dewetted solder joint
d. Disturbed joint
e. Excessive solder
ab. Insufficient solder
ac. Insulation damage
ad. Rosin solder joint
ae. Solder short

Match soldering tools and equipment on the right with appropriate uses.

___ 29. For removing oil, grease and flux from conductors and terminals both before and after soldering

___ 30. For cutting and pulling insulation from ends of conductors

___ 31. For removing wire insulation by heating and melting the material; prevents removing wire strands but cannot be used on insulation that will not melt

___ 32. For making electrical connections; most common type is 60/40 rosin-core solder with a center core of rosin flux to allow simultaneous application of both solder and flux

___ 33. For making mechanical connection prior to soldering; can also be used as a heat sink during soldering

___ 34. For cutting conductors

___ 35. For supporting a hot soldering iron when not in use

___ 36. For clamping and holding a printed circuit board or other component during soldering or other repair operations

___ 37. For ensuring a good electrical connection by cleaning and wetting all surfaces during soldering; not required if the solder contains a rosin core

___ 38. To control soldering iron tip temperature

___ 39. For making a strong mechanical connection to certain sleeve-type terminals

___ 40. For preventing electrical connections from becoming shorted to adjacent connections

___ 41. For removing melted solder from a terminal to be resoldered

___ 42. Sleeve-type insulation which, when heated, shrinks to form a snug fit over a soldered connection

a. Adjustable power source

b. Crimping tool

c. Diagonal-cutting pliers

d. Flux

e. Heat-shrink insulation

ab. Isopropyl alcohol

ac. Long-nose and needle-nose pliers

ad. Mechanical wire strippers

ae. Solder

bc. Solder sucker

bd. Soldering iron stand

be. Soldering vise

cd. Spaghetti-sleeve insulation

ce. Thermal wire strippers

Identify common hand tools as shown by your instructor.

43.

44.

45.

46.

47.

48.

49.

50.

ANSWERS TO UNIT TEST

1.	b	(A4)	22.	e	(A4)
2.	cd	(A4)	23.	ab	(A4)
3.	ab	(A4)	24.	c	(A4)
4.	e	(A4)	25.	a	(A4)
5.	ad	(A4)	26.	ac	(A4)
6.	be	(A4)	27.	ad	(A4)
7.	de	(A4)	28.	ae	(A4)
8.	c	(A4)	29.	ab	(A4)
9.	bc	(A4)	30.	ad	(A4)
10.	bd	(A4)	31.	ce	(A4)
11.	ae	(A4)	32.	ae	(A4)
12.	ac	(A4)	33.	ac	(A4)
13.	d	(A4)	34.	c	(A4)
14.	a	(A4)	35.	bd	(A4)
15.	ce	(A4)	36.	be	(A4)
16.	a	(A4)	37.	d	(A4)
17.	c	(A4)	38.	a	(A4)
18.	a	(A4)	39.	b	(A4)
19.	a	(A4)	40.	cd	(A4)
20.	b	(A4)	41.	bc	(A4)
21.	d	(A4)	42.	e	(A4)

43-50. To be evaluated by instructor (M3)

INSTRUCTOR'S NOTE: The following tools are suggested for student identification.

Needle-nose pliers
Diagonal-cutting pliers
1/4" nutdriver
Solder pencil
Wire stripper
5/16" nutdriver
Desoldering tool
Solder iron stand

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT III: PRINTED CIRCUIT BOARD REPAIR

UNIT OBJECTIVE

Upon completion of this unit the student should be able to repair printed circuit boards. This knowledge will be evidenced by completing the unit test and job sheet to specified score.

SPECIFIC OBJECTIVES

After completion of the lesson in this unit, the student should be able to:

1.1 Identify terms and definitions.

1.2 Identify characteristics of various types of printed circuit boards.

1.3 Distinguish between methods of mounting component parts.

1.4 Demonstrate the ability to:

a. Replace component parts by "like new" and crushing methods. (competencies B16, M4 and M5, JS 1.1)
b. Repair printed circuit board. (competencies B16, M4 and M5, JS 1.2)

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT III: PRINTED CIRCUIT BOARD REPAIR

CONTENTS OF THIS UNIT

A. Objective unit

B. References

C. Notes to the instructor

D. Lesson plan

1. Lesson 1: PRINTED CIRCUIT BOARD REPAIR

a. Information outline

b. Job sheets

JS 1.1: Replace component parts
JS 1.2: Repair printed circuit board

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Douglas-Young, John. Illustrated Encyclopedic Dictionary of Electronics. West Nyack, NY: Parker Publishing Co., Inc., 1981.

2. Fowler, Richard J. Electricity Principles and Applications. 2nd ed. St. Louis: McGraw-Hill, 1984.

3. Graf, Rudolf F. Modern Dictionary of Electronics. 6th ed. Indianapolis, IN: Howard W. Sams & Co., Inc., 1984.

4. Grob, Bernard. Basic Electronics. 5th ed. New York: McGraw-Hill, 1984.

5. Hughes, Fredrick W. Basic Electronics: Theory and Experimentation. Englewood Cliffs, NJ: Prentice-Hall, 1984.

6. Schuler, Charles A. Electronics: Principles and Applications. 2nd ed. St. Louis: McGraw-Hill, 1984.

7. Schuler, Charles A.; Richard J. Fowler. Basic Electricity and Electronics. St. Louis: McGraw-Hill, 1988.

8. Manko, Howard H. Solders and Soldering. New York: McGraw-Hill, 1964.

B. Curriculum guides

1. Hartman, Lonnie. Basic Electronics. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1987.

2. Robertson, L. Paul. Basic Electronics I. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1980.

3. Vorderstrasse, Ron. General Electronics Technician. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1987.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students can practice several tasks with old, scrap printed circuit boards.

   a. Replace two resistors on a board (two replacement resistors required).

   b. Cut a foil conductor to repair.

   c. Heat and lift a foil pad to repair.

2. As a demonstration, show students what overheating can do to foil pads while preparing the practice PC board.

B. Suggested supplemental materials

1. High Technology Soldering (videotape). Washington, DC: Consumer Electronics Group, Electronics Industries Association. (Available from EIA, 2001 Eye Street, N.W. 20006)

2. The Safety Factor (videotape). Katonah, NY: Circle Oak Productions, 1987. (Available with teacher's guide and quiz from 260 Katonah Ave. 10536, phone 914/232-9551)

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT III: PRINTED CIRCUIT BOARD REPAIR

LESSON 1: PRINTED CIRCUIT BOARD REPAIR

NOTE: Nearly all modern semiconductor electronics are fabricated on printed circuit boards. Defective parts must be removed from the PC board and new components installed. Circuit boards can be damaged and must be repaired. The ability to repair circuits and circuit boards is a valuable skill for the electronics technician.

I. Terms and definitions

A. Land--printed copper wiring attached to the surface of a printed circuit board

B. Pad--round, donut shaped, copper terminal connection point on a printed circuit board where component lead wires are attached

C. Phenolic board--plastic material (thermosetting resin) which becomes permanently hardened when subjected to heat; originally known as Bakelite™; used for printed circuit board construction

D. Printed circuit board (PCB)--plastic, fiber glass or phenolic board upon which copper strips interconnect between mounted components

E. Run (trace)--strip of copper conductor on a printed circuit board

F. SMD (surface mount devices)--miniature component parts mounted flat on the surface of a PC board

G. SMT (surface mount technology)--concept of miniature component parts mounted flat on the surface of a PC board

II. Types of printed circuit boards

A. Single-sided

1. Copper foil pattern on one side only (Solder connections made to this side.)

2. Component parts on opposite side of board (Part identification may be silk-screened on this side.)

3. Boards are easily repaired because parts are easily replaced.

4. Integrated circuits

a. Easily replaced if socketed

b. Difficult to replace if soldered in place

B. Double-sided

1. Copper foil on both sides of board

2. Component parts usually on one side of board (Part identification may be silk-screened on this side.)

3. Solder connections usually on the opposite side of board

   a. Large foil areas used for ground shields

   b. Can have a few parts on this side

4. Boards easily repaired since parts are easily replaced

5. Integrated circuits

   a. Easily replaced if socketed

   b. Difficult to replace if soldered in place

C. Multi-layer board

1. Multiple layers of foil and insulating material which are compressed under heat and pressure

2. Component parts usually on one side (parts identification screened)

3. Copper foil on opposite side of board

   a. Soldered connections to this side

   b. Foil areas used for grounded shields

4. Copper foil layers inside of board

   a. Soldered connections made to some points in layer

   b. Foil areas used for grounded shields

   c. Some layers make circuit connections

5. Boards are difficult to repair because of multi-layers, but parts may be replaced by the crushing method.

6. Integrated circuits

   a. Easily replaced if socketed

   b. Very difficult to replace if soldered in place

III. Methods of mounting component parts

A. Discrete component parts

1. Soldered connections

   a. Part leads inserted into holes on board

   b. Mechanically sturdy

2. Socketed connections

   a. Socket leads soldered into holes on board

b. Parts plug into sockets

c. Socket connections can corrode

d. Subject to vibration and shock damage

B. Integrated circuits

1. Soldered connection

a. Part leads inserted into holes on board

b. Mechanically sturdy

2. Socketed connections

a. Socket leads soldered into holes on board

b. Parts plug into sockets

c. Socket connections can corrode

d. Subject to vibration and shock damage

C. Surface mount technology (SMT)

1. New method of mounting components

a. Parts lie flat on PC board

b. No leads to insert into holes

c. No mechanical security

2. Miniature parts used

3. SMT repair techniques are beyond the scope of this lesson.

IV. Types of repairs

A. Defective components

1. "Like new" method

a. Crush and remove defective part with pliers.

b. Desolder leads from pads in circuit board.

c. Remove old leads from holes.

d. Install new part.

e. Solder new leads to pads.

2. Crushing (production) method

a. Crush and remove defective parts with pliers.

b. Bend old leads into hooks.

c. Install new part.

d. Bend new leads around hooks.

e. Solder new leads to old leads.

B. Pad or land pulling loose from PC board

1. Reasons for defect

a. Excessive heat softens adhesive

b. Solder pencil too large

c. Tip on work left too long

d. Excessive current

2. Repair method

a. Hook 22-gauge wire around component leads.

b. Solder to leads and to undamaged foil.

C. Break in foil conductor

1. Reason for defect

a. Stress, flexing board

b. Cut by sharp object

2. Repair method

a. Bridge with 22-gauge wire.

b. Solder wire to foil.

REPLACE COMPONENT PARTS

Equipment:

Solder pencil
Solder wick
Isopropyl alcohol
60/40 rosin-core solder
Typewriter eraser
Acid brush
Long-nose pliers
Diagonal-cutting pliers
Safety glasses
Two-replacement resistors
Printed circuit board with two damaged resistors

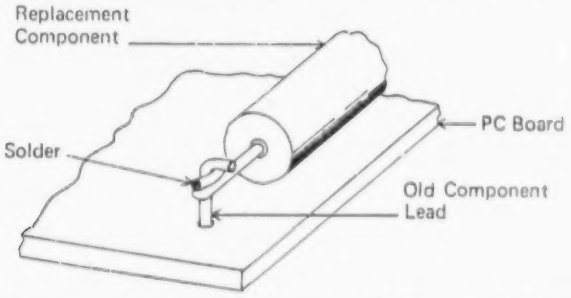
Procedure:	Evaluation 3	2	1	N
"Like new" method	—	—	—	—
1. Put on safety glasses. Prepare solder pencil--shape tip if required; clean tip; tin with fresh solder.				
2. Crush defective resistor. Turn board so that component side is down and foil side is up.	—	—	—	—
3. Desolder resistor lead.	—	—	—	—
a. Place solder wick over one pad and lead.				
b. Place solder pencil tip over solder wick. Melting solder will flow into wick.				
c. As wick saturates with solder, move wick to fresh area.				
d. When solder is removed from pad and lead, remove wick and solder pencil.				
4. Pull old component lead from pad with pliers.	—	—	—	—
5. For remaining wire lead, repeat steps 3 and 4.	—	—	—	—
6. Remove grease and rosin from pads with alcohol and acid brush. Remove oxides from the lead with typewriter eraser.	—	—	—	—
7. Measure distance between pads and bend component leads at right angles. Insert leads through holes in pads so resistor rests on component side of board. Spread lead ends slightly to prevent resistor from falling out of board.	—	—	—	—
8. Solder resistor lead to pad at each pad. Clip excess leads close to pad.	—	—	—	—
9. Clean soldered connections with alcohol and acid brush. Inspect soldered connections--there shouldn't be any rosin joints, solder bridges or cold joints.	—	—	—	—

Crushing method — — — —

1. Put on safety glasses. Prepare solder pencil--shape tip if required; clean tip; tin with fresh solder.

2. Crush defective resistor. Brush resistor debris away. Bend hook on end of both old wire leads. — — — —

3. Place new resistor in position and wrap new leads around old leads. — — — —



4. Solder new leads to old leads. Do not loosen wire in solder pads. Clip excess wire with diagonal-cutting pliers. — — — —

5. Clean soldered connections with alcohol and acid brush. Inspect soldered connections for rosin joints, solder bridges or cold joints. — — — —

Average of above evaluations* — — — —

*This average is the student's partial evaluation for competencies B16, M4 and M5.

REPAIR PRINTED CIRCUIT BOARD

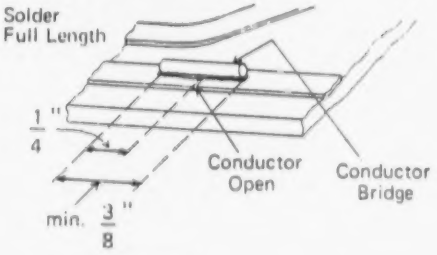
Equipment:

Solder pencil
Solder wick
Isopropyl alcohol
60/40 rosin-core solder
Typewriter eraser
Acid brush
Long-nose pliers
Diagonal-cutting pliers
Safety glasses
Printed circuit board with two damaged areas, one open conducting path, one lifted pad

Procedure:	Evaluation 3	2	1	N
Open conductor on circuit board				
1. Put on safety glasses. Prepare solder pencil.	—	—	—	—
2. Clean foil conductor to be repaired. Remove grease and rosin with alcohol and acid brush. Remove oxides with typewriter eraser.	—	—	—	—
3. Tin conductor each side of break. Bridge across the break by laying a piece of 22-gauge hook-up wire across break.	—	—	—	—

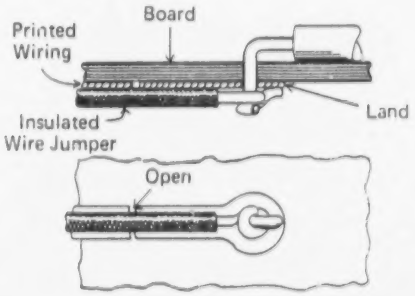
Solder Conductor Bridge Across Open as Shown

...or...

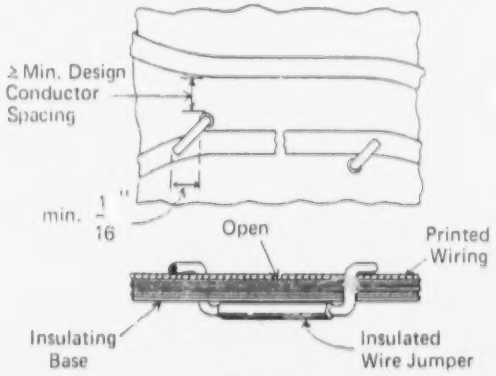


Solder Insulated Wire Jumper Across Open on Conductor Side of Board

...or...



Solder Insulated Wire Jumper Across Open on Component Side of the Board



4. Solder wire bridge to foil. — — — —

5. Clean soldered connections with alcohol and acid brush. Inspect soldered connections for solder bridges, rosin joints or cold joints. — — — —

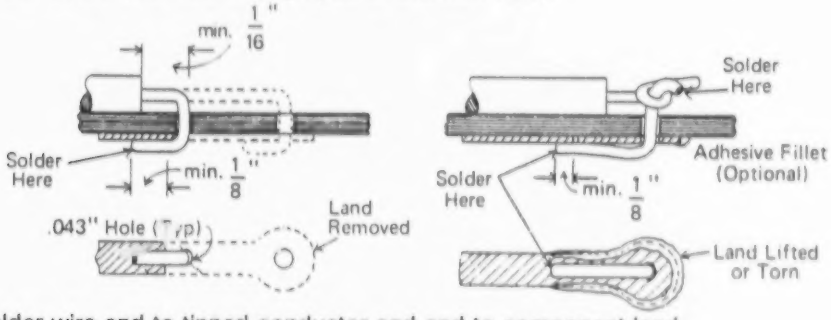
Removed or lifted land on circuit board

1. Put on safety glasses. Prepare solder pencil. — — — —

2. Clean foil conductor to be repaired. — — — —

3. Tin foil conductor. — — — —

4. Connect wire to component on circuit board. Run wire through hole on circuit board (old hole through pad or drill new hole). — — — —



5. Solder wire end to tinned conductor and end to component lead. — — — —

6. Clean soldered connections with alcohol and acid brush. Inspect soldered connections for solder bridges, rosin joints or cold joints. — — — —

7. Return tools and equipment to proper storage area. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competencies B16, M4 and M5.

MODULE: CIRCUIT CONSTRUCTION TECHNIQUES

UNIT III: PRINTED CIRCUIT BOARD REPAIR

UNIT TEST

Select the option which best answers the question or completes the statement.

___ 1. Which part of the printed circuit board is a round, donut-shaped terminal connection point where component lead wires attach?

a. Land
b. Pad
c. Phenolic
d. Run
e. None of the above

___ 2. The copper conductor strip on a circuit board is the _____ .

a. Land
b. Pad
c. Phenolic
d. Run
e. None of the above

___ 3. What term refers to the plastic material which becomes permanently hardened when subjected to heat?

a. Land
b. Pad
c. Phenolic
d. Run
e. None of the above

___ 4. Which type of printed circuit board is difficult to repair?

a. Single-sided
b. Double-sided
c. Multi-layer
d. Slotted
e. None of the above

___ 5. A printed circuit board with copper foil on one side and component parts on the other side is _____ .

a. Single-sided
b. Double-sided
c. Multi-layer
d. Slotted
e. None of the above

___ 6. Which method of mounting component parts inserts part leads into holes on the board?

a. Discrete components
b. Integrated circuits
c. Surface mount technology
d. a and b
e. None of the above

___ 7. Which method does <u>not</u> insert leads into holes?

a. Discrete components
b. Integrated circuits
c. Surface mount technology
d. a and b
e. None of the above

ANSWERS TO UNIT TEST (M5)

1. b
2. d
3. c
4. c
5. a
6. d
7. c